BROOKLYN BOTANIC GARDEN

PLANTS & GARDENS

PLANTS & GARDENS
BROOKLYN BOTANIC GARDEN RECORD

PROPAGATION for the HOME GARDENER

ANNUALS, PERENNIALS, TREES, SHRUBS, FERNS
FROM SOFTWOOD AND HARDWOOD CUTTINGS
SEEDS, ROOT CUTTINGS, LAYERING
GRAFTING AND BUDDING

Tools, Media, Hormones, Mist
The Future–Tissue Culture

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Vol. 40 May 1984 No. 1

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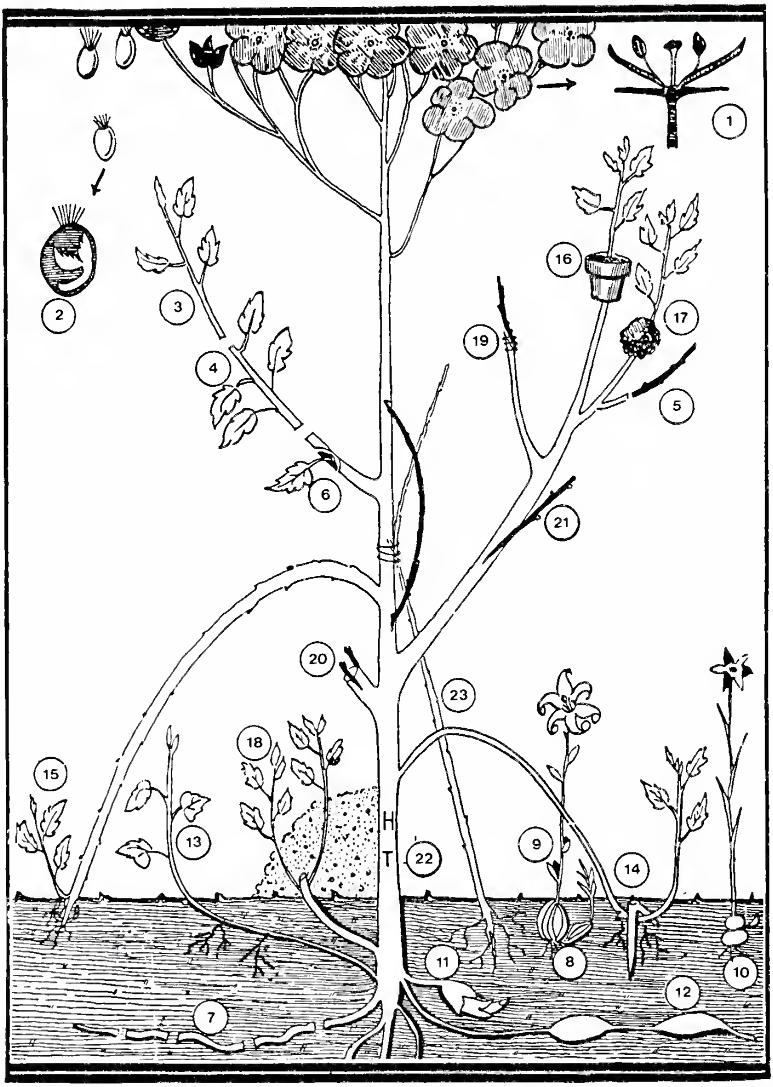

THIS IS PROPAGATION

By these methods our plants are multiplied

1. A "perfect" flower with both male and female parts; 2. seed; 3. softwood cutting; 4. half-ripe cutting; 5. hardwood cutting; 6. leaf-bud cutting; 7. root cuttings; 8. bulb; 9. bulblets; 10. corm; 11. tuberous root; 12. tuber; 13. sucker; 14. simple layer; 15. tip layer; 16. pot layer, or marcot; 17. air layer, or Chinese layer; 18. mound layer; 19. graft, whip and tongue; 20. graft, cleft; 21. graft, side; 22. budding; 23. inarching—a frequent natural graft. Not illustrated: division, leaf cutting, tissue culture (micropropagation).

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LETTER FROM THE BROOKLYN BOTANIC GARDEN

An African-violet leaf in a glass of water in the kitchen window must be a part of everyone's memories. This is a form of propagation with which we are all familiar, and an art that goes back for centuries. To quote George S. Avery in BBG's first *Handbook on Propagation* in 1957, "the rooting of cuttings, grafting and budding are all recorded in Pliny the Second's *Natural History*, written in the First Century A.D. Along with well verified facts Pliny mixed spurious statements, yet his *Natural History* deserves passing notice in this 20th century."

Guest Editor Alan D. Cook has gathered a star-studded cast of contributors for this entirely new handbook. Although many of the techniques are ancient, new methods such as micropropagation, more familiar as tissue culture, are now within reach of the home gardener.

"The original propagation device is our planet Earth. . . . Unfortunately, using earth alone, the propagator has no control over meteorological caprices that submit seeds and cuttings to excessive heat/cold and wetness/dryness," says Al Cook in the introduction to propagation devices. He, with his guest contributors, takes you step-by-step through all of the methods of replicating plants and controlling the environment.

Experiment with the various well-tried propagation techniques. You'll find them enjoyable and rewarding, both personally and in the numbers of new plants you make from the originals.

We thank Al for his thoroughness, and most of all for the wit and charm with which he imparts information.

May your gardening year be a good one.

Barbara B. Pesch

Editor

L. Lipp

From Glass of Water to Greenhouse . . .

PROPAGATION DEVICES

Alan D. Cook

The original propagation device is our planet Earth. Soil, particularly well-drained soil of good texture, with small spaces to hold water and slightly larger spaces to hold air, is an inexpensive and readily-available medium in which we plant seeds, entice layers to root, and stick cuttings (especially hardwood cuttings). Unfortunately, using Earth alone, the propagator has no control over meteorological caprices that submit seeds and cuttings to excessive heat/cold and wetness/dryness.

A plastic tent unit, a flat with appropriate medium, a wire framework to hold polyethylene plastic horizontally above the cuttings. Plastic, tucked securely under the flat, often need not be disturbed until cuttings root. The unit shown on opposite page, in a sunny greenhouse, has cheesecloth under plastic for partial shade. In lower-light areas the cheesecloth is omitted.

Small-Scale Devices

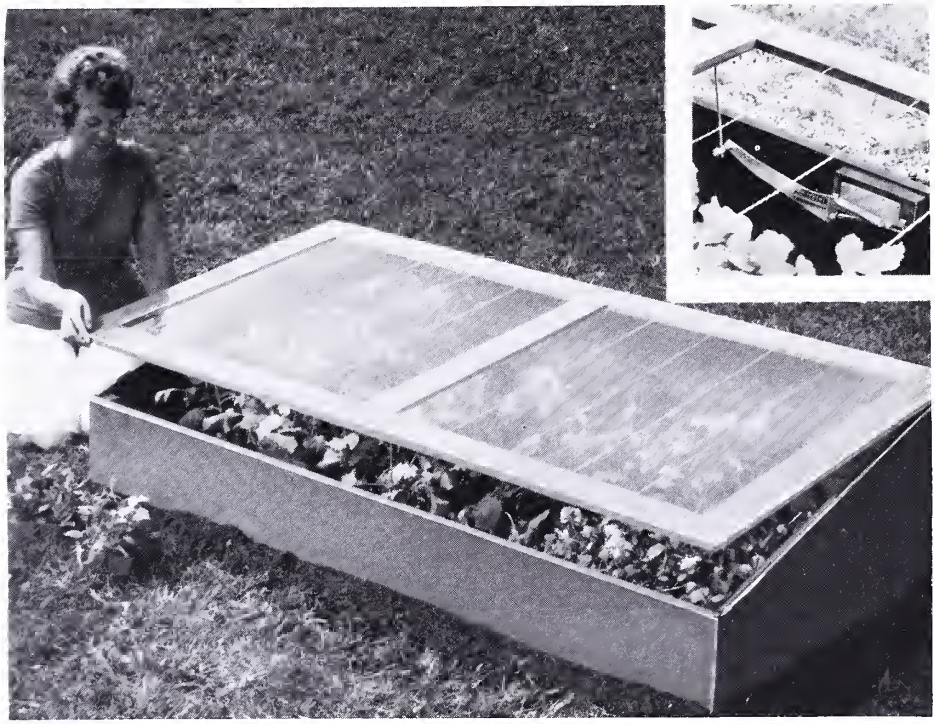
Many herbaceous and some woody plants (English ivy, willow) will root in water. Whose grandmother did not tie waxed paper or plastic over the mouth of a glass of water and stick stems of Joseph's coat or leaf petioles of African violet through holes in the cover? And some people think an avocado seed can germinate only if toothpick-suspended with round end down in a glass of water.

Efficacy of a glass of water is limited to propagation of relatively few plants because water doesn't contain much oxygen (essential to cell growth). So an early propagator put some soil in a pot or box (flat) for better control of seeds and cuttings. Sand mixed with leafmold was good, pure sand better, and sandy soil worked best. . . and now we have almost as many rooting/seeding media as there are propagators. Peat, perlite, vermiculite, shredded styrofoam, sphagnum moss, cinders, sawdust—the old propagation flat can't hold them all.

Humidity

For humidity control, glass jars upturned over earth-planted seeds and cuttings or glass panes over seed flats led the way to a gaggle of plastic gimmicks.

A simple device for a few seeds and one or a very few cuttings is a plastic cup with a drainage hole punched in the bottom, with clean medium soaked and drained, in a small plastic bag tied at the top to form a small watertight cell.



W. Atlee Burpee Co.

An easily assembled cold frame kit. Heating cable or mat turns it into a hotbed. The inset shows an automatic ventilating device.

Since water from the medium (and the cuttings) can condense on the plastic and run down the sides, some operators put the medium in the bag and put the bag in a pot (for stability), thus allowing condensation water to reenter the medium. Clear plastic refrigerator dishes and boxes are also convenient rooting and seeding chambers.

About 1950, Lewis Lipp (Guest Editor of the first BBG *Handbook on Propagation*) began to use plastic tents over single flats and then bigger plastic tents over several flats. (Pots will do as well as flats.) Construct a framework of wood or heavy wire (bent coat hangers will work for small units) to hold clear polyethylene film above the flats. The top of the structure should be flat rather than rounded so condensation will drip back down onto the surface area rather than running down the sides. Plant seeds or cuttings in properly moistened medium in the containers and gently water. Place plastic over the framework and tuck beneath the edges of the flats. Further watering may not be necessary for several weeks. Flats, medium and cuttings must all be as clean as possible to reduce chances of fungal diseases.

A problem with plastic tent units is maintaining an appropriate relationship between light and humidity. Indoors, humidity levels are easily kept high, but even with supplemental light it is not easy to obtain optimum illumination. Outdoors, light is no problem but sunlight increases temperature inside the tent, lowering humidity. Thus, shading of some sort, by placement of the unit in a shady place or by introducing a sun shield, is in order and we're back to insufficient illumination.

The larger the enclosure of a plastic structure, the greater the light-humidity problem. So small systems, as a plastic cup over a pot, or a pot within a one-quart freezer bag, are often more successful, but obviously less productive.

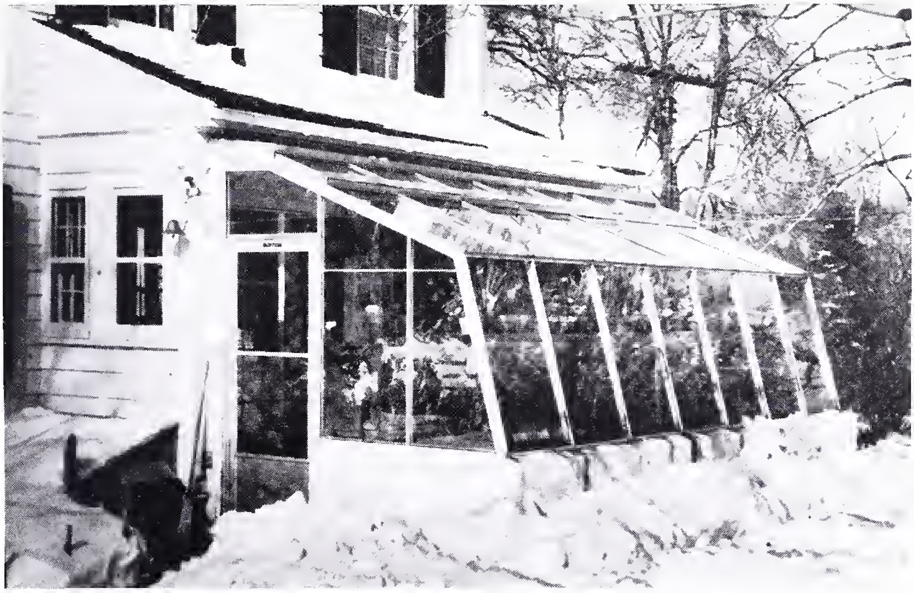
Light

For indoor plastic tents, smaller units can be placed in a sunny window as close to the glass as possible. Curtains or even window screens can reduce light intensity drastically. East windows are the best choices; shading may be necessary in south or west windows on sunny days.

Artificial lighting is never as bright as humans think, but plants aren't fooled. A good system is to provide as many fluores-

W. Atlee Burpee Co.

A compact electrically heated indoor greenhouse.



Lord & Burnham

A lean-to home greenhouse can be independently heated or use heat from the house. There is accessibility in all seasons and weather. There should be an outside door as well as one into the house, and the south or southeast side of the house offers the best location.

cent lamps as space will allow, alternating ordinary tubes of cool white and warm white in equal quantities. Place lights 8 to 12 inches above the seeds or cuttings. Some growers use continuous illumination, others prefer 16-hour periods of light.

On a large scale, growers incorporate fog or mist into the structure, or simply use mist out-of-doors with wind baffles on the sides of the propagating area. Fogging machines are used by some commercial operators, but misting systems are available for the amateur as well (see pp. 45 and 76).

Small-Scale Structures

A number of commercial seed kits, miniature greenhouses, and other small indoor and/or outdoor propagation aids, with instructions, are on the market, both in local garden stores and from various mail order firms (see p. 76).

Long before the plastic tent, propagators used boxes with hinged or removable glass sashes for lids. Outdoors, these are called cold frames. If given heat (by fermenting organic matter such as manure beneath the propagating medium as in the old days, or by electric cables or mats in the present) they become hotbeds. The light-humidity problems of plastic tents apply to cold frames and hotbeds.

Cold frames and hotbeds may be purchased from various commercial firms (see p. 76), or can be homemade. Preservative-treated wood is more durable than untreated. You can purchase Cuprinol and treat lumber yourself. Don't use creosote or pentachlorophenol—they're toxic to plants.

A number of propagation books and pamphlets give directions for cold frame and hotbed construction; see p. 72 and/or check local libraries, nurseries, and by all means your County Cooperative Extension Agent for information. If you install electric cables or mats for bottom heat, be sure the wiring conforms with local building codes.

Greenhouses are the most sophisticated propagating structures, also the most expensive and demanding of attention. (Some states allow state tax credits for attached solar greenhouses.) Greenhouse and greenhouse equipment suppliers and how-to books are listed on p. 76. ⁂

It makes a difference . . .

Propagating Media

A propagating medium must 1) hold seeds and cuttings in place during germination or rooting, 2) have small spaces (micropores) to hold water against the pull of gravity, and 3) have larger spaces (macropores) to hold air after excess water drains away.

In addition, an ideal medium should be clean, free of disease organisms and weed seeds, readily available, and lightweight for easy handling. If it meets all the above and is also inexpensive, it is an ideal material.

Soil and Sand

Soil is inexpensive and readily available but is not always properly porous and is never clean. Bank sand and beach sand, if copiously rinsed to remove clay and salt, are usually of decent porosity but are not clean.

Various chemical and physical sterilization and pasteurization processes are used by commercial propagators. A simple method for the amateur is baking moist material (sand or soil) in a conventional or microwave oven. Put medium three inches deep in a pan, enclose in a tough plastic poultry-baking bag (to contain odors) at a temperature and time combination sufficient to thoroughly bake a large potato.

Builder's sand, especially #7 silica sand, is a good medium and is usually clean enough to use as is. It's cheap and usually easy to obtain, but heavy.

Peat Moss, Sphagnum and Others

Other popular media are vermiculite, perlite, ground styrofoam, peat moss, and sphagnum moss.

Peat moss, the coarse, brown good stuff that comes compressed into bales, is popularly used either alone or in mixtures for rooting broadleaf evergreen cuttings, especially those of the family *Ericaceae* (rhododendrons, azaleas, blueberries, pieris, heather, among others).

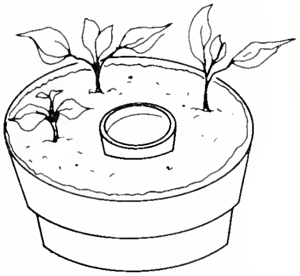
Sphagnum moss, milled or screened (rubbed through ¼-inch hardware cloth), is ideal as a seeding medium. It holds immense amounts of water without excluding air, is incredibly light, and has a built-in antidamping-off mechanism (which is lost if sterilized). Even if you don't use sphagnum moss for a seeding submedium, at least consider sprinkling a thin layer atop the seeds.

All of those materials and others are employed, singly and in an infinite array of mixtures, by propagators around the world. Some use different media for different plants.

Enterprising horticultural suppliers offer cubes, pellets, trays and other ready-to-plant propagation aids for both seeds and cuttings. They fill all the criteria for good media, but do cost more. And somehow they take a bit of fun out of propagating for some of us.

In the end, whatever medium works for you is the one to use. ✤

The Forsyth Pot



K. Kling

The Forsyth rooting pot was popular in pre-plastic days. A small clay pot with drainage hole corked or puttied was placed inside a larger pot (with conventional drainage). Rooting medium filled the larger pot while the smaller was kept full of water. Cuttings stuck in the damp medium received a steady supply of water as it seeped through the porous clay of the small pot. ✤

Roche

Pricking out seedlings from can to greenhouse flat. (These seedlings could well have been pricked out at an earlier stage.)

RAISING ANNUAL AND PERENNIAL PLANTS FROM SEED

The easiest, cheapest, most common method of producing vegetables and annual and perennial flowering plants.

Frances M. Miner

Growing plants from seed is the most universal method of propagation. All gardeners at one time or another grow some of their plants in this way, though the techniques employed often are hit or miss—as are the results. By following a few common-sense procedures, most gardeners can increase the numbers of kinds of plants they can raise from seed, and greatly improve their chances of success.

Saving Seed

For most gardeners, saving seeds from their own plants is hardly worth the trouble. The great majority of our present-day vegetables, annuals and perennials are hybrids of mixed ancestry that will not come true from seed collected in the home garden. Results with such seed will be very disappointing. Seeds purchased from seedsmen are grown by special techniques to ensure that they will produce the kinds of plants desired. However, if one is certain that some of the home garden plants are pure species, or pure lines which will come true, it is possible to save home-grown seed, or seeds of many species that grow in the wild. The seed should be collected as soon as ripe, then cleaned and stored in containers in a cool dry place until ready for planting.

Seeds purchased from reputable seedsmen are much more satisfactory, and, except for rare or new varieties, are very reasonable in price.

Leftover or home-collected seeds can be air-dried for a few days, then stored in airtight jars or plastic bags in the refrigerator often for a year or two, sometimes more.

When to Plant Indoors

The urge to get something planted reaches a seasonal high in mid-winter, around January, spurred on by the arrival of new seed catalogs and articles on planting in garden magazines. As a result, many gardeners start seeds indoors too early. In warmer climates, where spring arrives early, seeds can be started at this time, but in temperate climates, as in the latitude of New York City, March is soon enough to plant indoors. Plants will then be ready for setting out-of-doors by the middle of May or a little later.

Very small seeds, or those of plants requiring a long growing season are the ones best suited to starting indoors. Seeds of fast-growing plants can be started out-of-doors when the soil is ready for planting and danger of frost is past.

Seed packet directions give before-frost times for planting indoors. Check with local cooperative extension agents or seasoned gardeners, and lean toward the safer dates. Or gamble with earlier times, but be prepared to pay the price of losing.

Containers and Soil

Almost any kind of container that provides adequate drainage can be used. Greenhouse flats, flower pots or cans with holes punched in the bottom are all good. Containers should be at least three inches deep, otherwise they may dry out too fast. Seeds are planted in such containers with the understanding that they are to be transplanted once, while very small, to other containers in which they will grow to a size suitable for final transplanting to the garden.

Over the holes in the bottoms of the containers are placed pieces of broken clay pots, gravel or other coarse material (a wad of old pantyhose material is ideal) to ensure drainage. The container is then filled to about a half-inch from the top with any good, light, friable soil. If available soil is rather heavy, it can be lightened by mixing in some sand or finely ground peat moss. A common mixture that has been found satisfactory consists of one part each of sand, garden soil and leafmold or peat moss. Since garden soil is never "clean," see p. 8 for substitutes and sterilization recommendations. Milled sphagnum moss is terrific for holding water and air and reducing chances of fungal diseases.

Planting

Make a strong effort to sow seeds thinly. An all-to-common error is planting too many per unit of surface. Even in rather small containers, such as four-inch pots, it is best to plant the seeds in rows, as this makes for easier handling when pricking out. As shown in the diagram, six short rows of seeds can be sown in one 6-inch bulb pan (shallow flower pot). All plantings should be labeled; it is easy to forget, and often hard to recognize small seedlings.

The best way to judge depth of planting is to take a good look at the seed and plant it about two times its diameter. For small seeds this means a very thin covering of soil indeed, or no covering at all for tiny seeds such as petunia. To guard against pre-emergence damping-off, a condition in which fungi kill seeds before or soon after they break through the soil, the seeds and/or medium may be treated with commercial chemicals, if one cares to use them (ask your garden supply dealer or county cooperative office for currently approved products). Remember sphagnum moss for planting seeds onto and covering them with. Another way to lessen the threat of damping-off is to provide good air circulation and plenty of light.

Watering

Watering is one of the chief reasons for success or failure with seedlings. The soil should

Buhle

Watering from below by setting pots in pan of water.

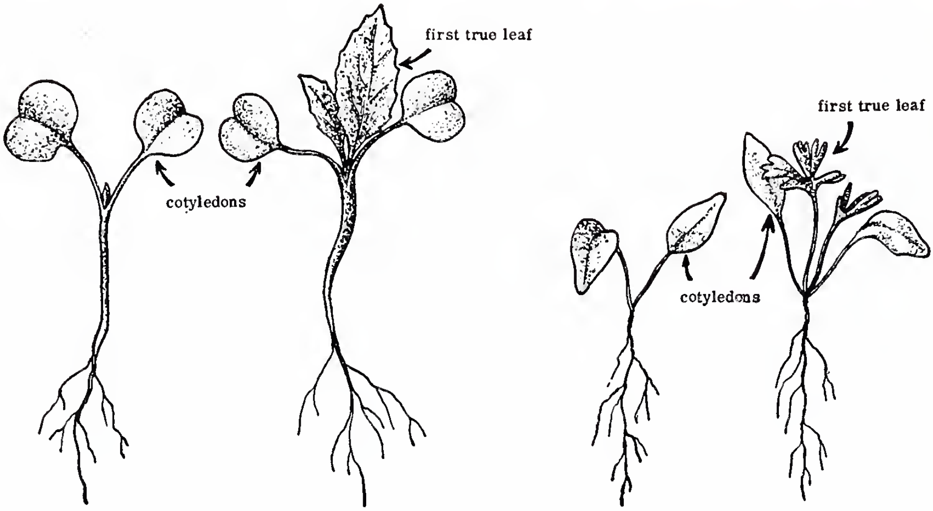
be moist but not wet at the time the seeds are planted, and it should be kept as close to this state as possible at all times from planting on. Small seedlings dry out very quickly—and once is often fatal. On the other hand, roots must have air as well as water, and if the soil is kept soaked for very long, the plants literally drown. There is no set rule as to times for watering—the condition of the soil determines whether to water or not. On bright warm days plantings may have to be watered two or three times, on dark damp days not at all.

As soon as the first seedlings appear in a pot it should be set where it will get bright light from fluorescent tubes a few inches above the plants or from sunshine. This is a point overlooked by many gardeners but it is necessary to ensure the growth of good sturdy seedlings. If it is not done, the seedlings grow long and spindly, a state of affairs almost every gardener has encountered. Of course, extra care must be taken to see that the seedlings do not get too dry.

Pricking Out, the First Transplanting

Most seedlings when first up show two small "seed leaves." These are followed in due time by the first true leaves, which are characteristic of the plant. When these first true leaves are visible is the best time for pricking out. This transplanting operation checks the growth of the seedlings temporarily, making them grow into more compact plants. The seedlings are lifted, one or a very few at a time, from the starting containers with a pencil or small flat stick (a pot label is good) and planted one-by-one in larger containers. To handle without damaging, the tiny plants should be held by a leaf (not the stem) between thumb and forefinger. Holes of appropriate depth and about two inches apart (more for fast growing plants such as tomatoes, marigolds, etc.) are made in the soil of the new containers and the seedlings inserted. Roots should not be exposed to the air any longer than is absolutely necessary. After the seedling is inserted in a hole, the soil should be gently firmed about the roots, leaving the surface soil loose. Individual pots (paper, peat, clay, etc.) may be used instead of multiple-plant containers.

Seedlings are of two types—those form-

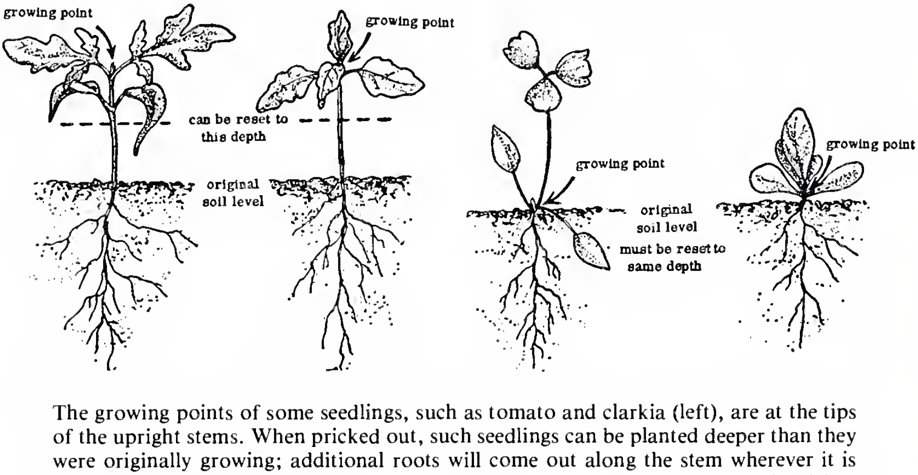


Drawings by Peter K. Nelson

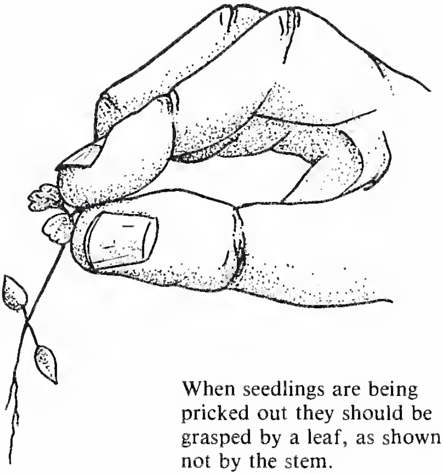
The first leaves which appear on many seedlings are the so-called seed leaves (cotyledons) which often bear no resemblance to the later leaves. When the first true leaves, which are more or less typical of the later leaves, appear the seedlings can be pricked out.

ing a rosette, with the growing point at the base of the cluster of leaves, and those with an upright stem having the growing point at the tip (see illustration). The first must be planted out exactly the same depth they were growing in the starting containers. If they are planted deeper than this, the growing points are buried and the seedlings may die. The other type may be planted out to the first leaves; the growing points are at the tops of the stem and will not be buried.

When the time for final transplanting to



The growing points of some seedlings, such as tomato and clarkia (left), are at the tips of the upright stems. When pricked out, such seedlings can be planted deeper than they were originally growing; additional roots will come out along the stem wherever it is under the soil. Growing points of other seedlings, such as columbine and petunia (right), are at the centers of rosettes of leaves, at the soil line. Such seedlings must be replanted to the same depth as they were originally growing so as not to bury the growing plant.



When seedlings are being pricked out they should be grasped by a leaf, as shown, not by the stem.

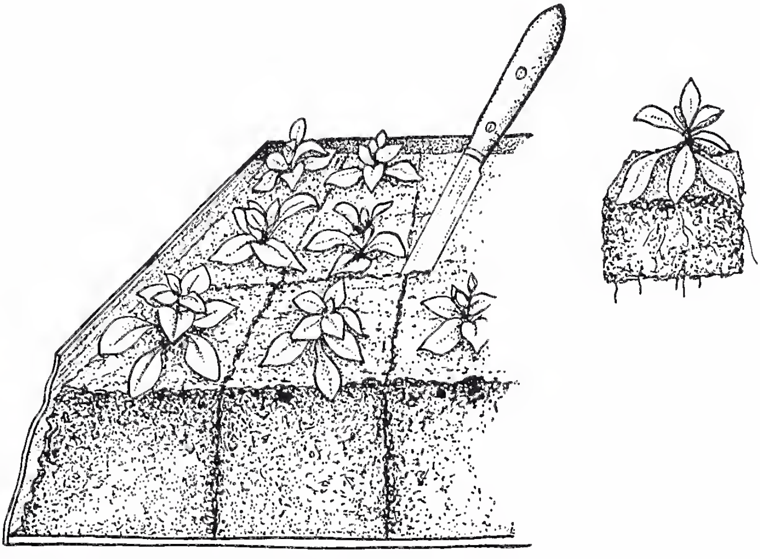
the garden has arrived, the medium in which the seedlings are growing can be cut like a cake, with a block of soil around each plant, and the plants lifted and set in their permanent places.

If plastic, paper or clay pots are used, they must be removed, and root balls should be *gently* disturbed by squeezing or teasing roots to encourage new roots to grow into the new soil environment. Peat pots should be torn off below the pots' soil surface and squeezed but preferably removed.

Hints on Planting Out-of-Doors

Seeds to be planted directly in the garden can be put in rows and then thinned out, but a more economical method is to plant two or three seeds at each point along the row where a plant is wanted. When the seedlings are up the extra plants can be pulled out or cut off, leaving the sturdiest. Depth of planting again is the most important point in oudoor seed sowing. Fine seeds are sprinkled on the surface and raked; slightly larger ones are covered by a quarter-inch of fine soil; and those the size of radish or zinnia can sprout through an inch of cover.

Outdoor germination can be hastened by hotcaps, cloches, and other homemade or commercial covers. A shingle or board over seeds (except those that need light) is good, but one must check daily for the first signs of sprouting. Then the board should be propped up on one side for a day, then removed. ❧



When seedlings which have been pricked out into flats are ready for transplanting to garden, the soil in the flat can be cut like a cake, and each plant removed with a block of soil around its roots. Many types of peat pots, cubes, bands, and other devices on the market can be used, thus eliminating this step.

GROWING TREES AND SHRUBS FROM SEED

Lewis F. Lipp

Trees and shrubs can be propagated in various ways. Nature's methods of perpetuating a species are through seeds and layering. The remaining artificial methods are the use of cuttings, grafting and bud-grafting. Hybrids rarely if ever come true from seed, and for this reason are propagated vegetatively. Also, trees and shrubs reach flowering size sooner when propagated vegetatively than when grown from seed. Trees, when raised from seed, are in most cases healthier and apt to live longer than plants grown from grafts. Seedlings of a given species are not identical; sometimes they will exhibit considerable variation in size, vigor, hardiness and other characteristics. Sometimes a truly superior plant will turn up.

Before discussing the various kinds of seed and their treatments, I wish to point out that, to promote favorable growth of the seedlings, the original environment of the parent plant should be recreated as closely as possible.

Following is a classification of seeds and brief directions on handling each type.

Fleshy Seeds

Fleshy seeds, such as oak (*Quercus*), chestnut (*Castanea*) and horse-chestnut and buckeye (*Aesculus*) usually break dormancy rapidly and should be sown soon after harvesting. If this is impractical, mix seeds with moist sand and store out-of-doors in a container over the winter months; in early spring plant in drills (literally a hole drilled in the soil). There are exceptions, as in the case of white oak, which should be sown immediately; the acorns germinate shortly after harvesting.

Hard-Coated Seeds

Viburnum, holly (*Ilex*), dovetree (*Davidia*), cotoneaster and plum, apricot, cherry and peach (*Prunus*) are examples of hard-coated seeds. Pick the ripe fruits and soak in water for several days. As the fruit flesh decomposes, run the fermenting mass through the fingers. This will help separate seed from pulp, and will permit the pulp and non-viable seed to rise to the surface, while the viable seed will go to the bottom of the container. A stream of water from a garden hose placed a few inches below the surface of the water will float away the pulp and poor seeds, leaving the good seeds. In some instances seeds of these species germinate in spring after a period of low temperatures. With these the natural process can be imitated by sowing the cleaned seed in the fall in a drill and lightly covering with soil. Placing a wire screen over the planting will protect the seeds from rodents and birds. An alternative is to mix seeds with moist material (sand, milled sphagnum moss, sawdust, or screened peat moss) in a plastic bag, properly labelled, and store in the refrigerator until early spring planting. [*Ed. note:* This process is called stratification (See p. 17 for discussion).]

In some of the species of cotoneaster, hawthorn (*Crataegus*), holly and viburnum the seeds have a double dormancy; also, the degree of dormancy varies from crop to crop. One recommendation is that the cleaned seeds be sown in the autumn. While a few seeds may germinate the following spring, most will germinate the second spring or even the third. Another practice is to place the seeds in moist peat, sawdust or sand in a polyethylene freezer bag. Tightly seal, label and store at room temperature for approximately 120 days. Then place in the refrigerator at 34° to 40°F for another 120 days.

Winged Seeds

Species such as fir (*Abies*), spruce (*Picea*), pine (*Pinus*) and maple (*Acer*) have winged seeds. Maple seeds, after they fall to the ground, appear to require a moist mulch for germination; if the moisture content is reduced, germination is delayed. For this reason summer-ripening species, such as red maple (*Acer rubrum*), can be sown after collecting. Sugar maple seeds (*Acer saccharum*), which ripen in the autumn, require a period of cold before germinating. Dormancy in some species, such as the paperbark maple (*A. griseum*), can be overcome somewhat by gathering seeds before they are fully ripe and stratifying at once.

Cones of fir, spruce, pine and other conifers are usually picked from the tree just as they begin to open. The seeds will be shed as the cone scales open. The wings of these seeds are removed by rubbing (or left on by some propagators) and the seed is then stored until spring at 34° to 40°F in moist peat, sawdust or sand. It is then broadcast on well-drained, sandy loam soil and covered with a thin layer of sand or soil. During the first growing season, the seedlings should be lightly shaded and mulched with a thin layer of pine needles. Experience has proved that cold stratification improves germination of most conifers.

Very Fine Seed

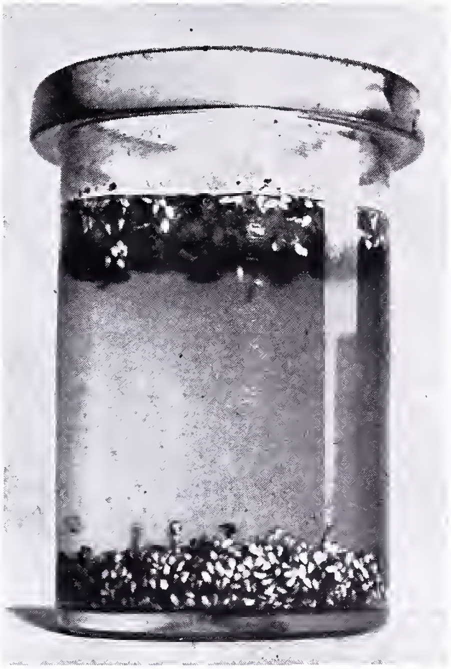
During early autumn the dehiscent seed capsules of mountain-laurel and other *Kalmia* spp., rhododendrons, azaleas, and pieris open nearly unnoticed, dispersing their tiny seeds. Often the collector is too late to harvest them. The ideal time to collect these seeds is when the capsules first turn brown. Place in paper bags, label, and store at room temperature. Capsules will soon open and release seeds.

Plant seeds in a greenhouse or indoor light unit in autumn or early winter or out-of-doors the following spring.

Use a mixture of two parts peat moss screened through ½-inch mesh and one part perlite in a clean flat or pot with ¼"-to-½" of milled or screened (¼-inch mesh) fresh sphagnum moss on top. Water gently but thoroughly and allow to drain. Distribute the seeds lightly and evenly (over-seeding is all too easy) over the sphagnum moss layer. Water with a fine mist. Do not cover seeds with medium of any sort. Place a sheet of plastic film over the flat and set it where the temperature is about 70°F. When the seedlings begin to appear, remove the plastic and keep the flat moist. Provide sufficient light and air. The young seedlings can be transplanted into a mixture of two parts Michigan peat, two parts imported peat moss and one part sand. The use of this mixture for ericaceous plants (rhododendrons, azaleas, pieris and others) reduces weeding and damping-off. Seedlings can be transplanted—spaced on one-inch centers in flats or put into small pots—any time after forming two or three leaves. A mulch of pine needles, ground corncobs, wood chips or other coarse organic material is beneficial for ericaceous plants after they are set out into the ground.

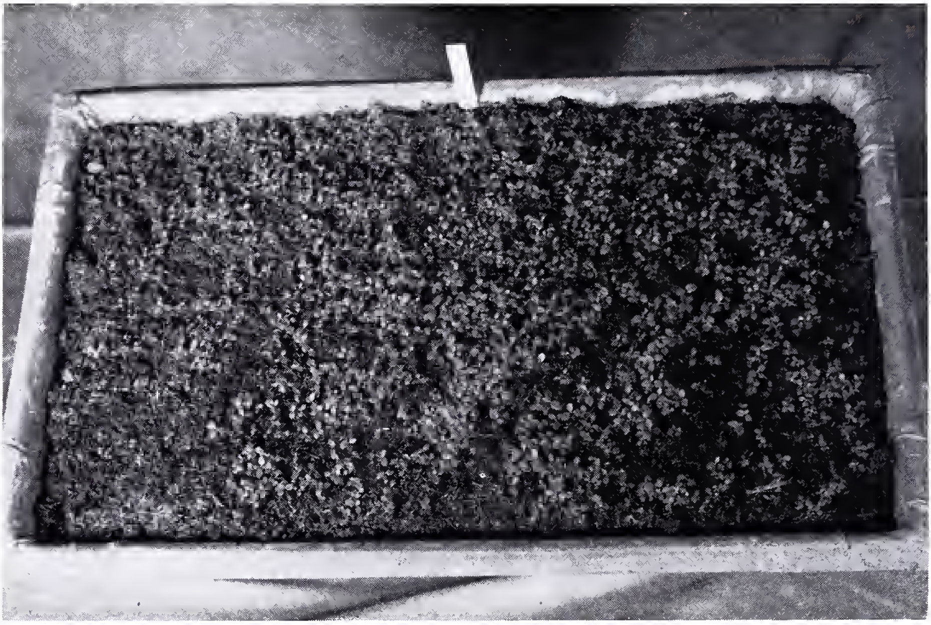
Spirea, hypericum and hydrangea also fall into the fine-seed classification and require the same technique in sowing. However, the seedlings should be transplanted into a sandy soil instead of into the peat-moss mixture recommended for ericaceous plants.

Raising trees and shrubs from seed requires time and patience, yet will give considerable pleasure to all who enjoy turning up the unexpected.

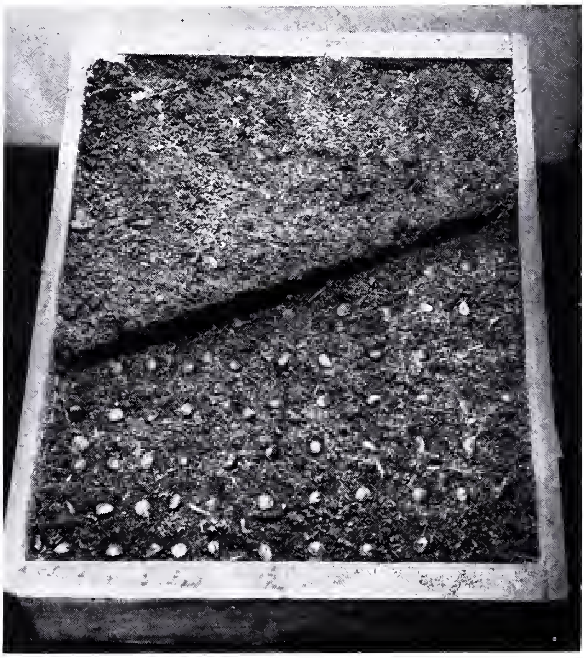


Buhle

Separating seed from fruit. Left in water for a few days fruits become soft and seeds can be squeezed out from pulp by hand. Sound seeds generally sink, bad ones float.


L. Lipp

Rhododendron seedlings growing on sphagnum in flat.


Buhle

Stratified magnolia seeds planted in flat; partially uncovered to show spacing and depth of planting.

Woody Plant Seeds Which Should Be Stratified

Stratification is the storing of seeds for a period of after-ripening in a moist medium at a low temperature, usually a little above freezing. Seeds were formerly always stratified in layers, hence the term stratify, but now they are most often mixed with the medium.

Stratify at 35° to 40°F, which is about the temperature range of the average home refrigerator (planting in autumn usually takes the place of stratification):

Name	Stratification (Days)
Abies spp. (fir)	60–90
Acer palmatum (Japanese maple)	100–120
Acer platanoides (Norway maple)	90–120
Aesculus spp. (horse-chestnut, buckeye)	120
Amelanchier spp. (shadbush)	90–180
Asimina triloba (pawpaw)	100
Berberis spp. (barberry)	15–40
Carpinus spp. (hornbeam)	100–120
Celastrus spp. (bittersweet)	90
Celtis spp. (hackberry)	60–90
Chionanthus virginicus (fringe-tree)	90–120
Cladrastis lutea (yellow-wood)	90
Cornus florida (flowering dogwood)	100–130
Cornus kousa (Japanese dogwood)	120
Diospyros virginiana (persimmon)	60–90
Elaeagnus angustifolia (Russian olive)	90
Fagus spp. (beech)	90
Fraxinus spp. (Ash)	30–90
Juglans nigra (walnut)	60–120
Juniperus spp. (juniper)	90–120
Ligustrum spp. (privet)	60–90
Liquidambar styraciflua (sweetgum)	30–60
Liriodendron tulipifera (tulip tree)	70
Lonicera spp. (honeysuckle)	30–60
Magnolia spp. (magnolia)	120–180
Malus spp. (apple, crabapple)	30–90
Nyssa spp. (tupelo)	60–90
Picea glauca (white spruce)	60–90
Picea pungens (Colorado spruce)	30–90
Pinus spp. (pine)	30–90
Prunus spp. (apricot, cherry peach, plum)	60–120
Pseudotsuga menziesii (Douglas-fir)	30–60
Rosa spp. and hybrids (rose)	120 or more
Syringa vulgaris (lilac)	30–90
Tsuga canadensis (hemlock)	60–120
Vitex agnus-castus (chaste-tree)	90

Some seeds benefit by being stratified for a time at a high temperature before being given the cold treatment. The following are among these:

Name	Warm °F	Warm Days	Cool °F	Cool Days
Cotoneaster spp. (cotoneaster)	58–77	90–120	33–41	90–120
Crataegus spp. (hawthorn)	77	120	41	180
Halesia spp. (silverbell)	68	30–90	41	60–90
Lindera benzoin (spicebush)	77	15–30	34–41	90–120
Rhodotypos scandens (jetbead)	86	30	41	90
Sorbus spp. (mountain-ash)	77	90	41	90
Taxus spp. (yew)	68	90	41	120
Tilia spp. (linden)	68	120	41	90–150
Viburnum opulus (European cranberry bush)	68–86	60–90	41	30–60
V. trilobum (American cranberry bush)	68–86	90–150	41	60

GERMINATING DIFFICULT SEEDS

Fred C. Galle

Fortunately, most of the plants grown from seed are annuals and other plants which germinate readily and under a wide variety of conditions. Simple methods are sufficient for these. However, these simple germination practices often do not work with some perennial seeds, and with seeds of many woody plants. A brief discussion of the factors involved may be helpful.

Seed Dormancy

The term dormancy is applied to the inability of a seed to germinate. Dormancy may be due to unfavorable environmental conditions, or to factors within the seed itself. Some of the environmental factors which influence germination are moisture, temperature, oxygen and, in a few cases, light. These factors must be in proper balance for all seed germination. Water and oxygen are, of course, necessary for all growth. (See p. 8 for more about them in soil mixtures.)

Temperature and Light

Some seeds have peculiar temperature requirements. While most germinate over a rather wide range of temperatures, others are somewhat more particular. Optimum temperatures for germination of some seeds are given on p. 17.

Likewise, most seeds will germinate in either light or darkness, but a few require light in order to germinate, while others are inhibited by it. [*Ed. note:* Japanese umbrella pine *(Sciadopytis verticillata),* will not germinate in the long days of summer.]

Hard Seed Coats

Internal dormancy is not often considered by gardeners and may be the cause of apparent failure in growing plants from seed. One of the commonest causes of internal dormancy is a hard seed coat. A seed coat is protection for a seed, but it can also prevent germination by keeping out water and air,

Photos by author

Many seeds need to be kept cold and moist for a period of after-ripening before they will germinate. This cold treatment is easily accomplished by mixing clean seeds with moist peat moss, wrapping in plastic, and placing in refrigerator. Label for bag should mention type of seed, date collected, and date placed in refrigerator.

Heavy seed coats such as those of *Camellia sasanqua* seeds (center) can be carefully cracked with a nutcracker or nicked with a knife or a small file.

and even by restricting the embryo from expanding and growing. In many cases the effect of the hard seed coat can be overcome by cracking the seed coat (being careful not to crush the contents), or by nicking it (scarifying) with a knife or file. Usually it is necessary only to make a small break in the coat to overcome the dormancy. [*Ed. note:* Here's a method for scarifying small quantities of hard coated seeds quickly and easily: roll a sheet of emery cloth or sand paper with rough side in, and insert it into a tall jar or can of about one-quart capacity; drop in seeds, cap the jar or can, and shake vigorously until seed coats are worn thin.] Other methods are to soak the seeds in nearly boiling water or in concentrated acids. These methods are not recommended for the amateur because the times of soaking are often quite critical and too-long soaking can easily kill the seeds; handling concentrated acid involves, of course, a certain risk to the operator.

Other Types of Dormancy

The food storage tissue (endosperm) in some seeds acts very nearly like a hard seed coat; this type of dormancy can usually be overcome using the same methods.

In some seeds the immature plant (embryo) itself is not completely organized at the time the seed is shed. In most such cases not much can be done to speed up germination. For example, ginkgo and English and American hollies will germinate only after the embryo has had an opportunity to mature at favorable temperatures and humidity. This may take as long as two or three years.

The causes of dormancy in many seeds are not always obvious. These seeds are said to require a period of after-ripening before they will germinate. No doubt certain chemical and physical changes take place during after-ripening, but little is known of their exact nature. The home gardener need not be concerned with this beyond knowing that after-ripening can often be brought about or speeded up by subjecting the seeds to low temperatures for certain periods of time. This cold treatment is called stratification. Seeds can be stratified in damp sand, shredded sphagnum, peat moss, or a mixture of peat moss and sand. The medium must be moist, but never saturated. The seeds may be placed in layers in the stratifying medium or may be mixed with it. If they are very small, it may be advisable to fold them in a piece of cheesecloth before stratifying. Containers may be greenhouse flats, glass jars or plastic bags. Jars and bags are most convenient for the amateur, as they can be easily stored in a refrigerator. Jars should have covers to prevent drying-out of the seeds, but they should not fit so tightly as to exclude air. With plastic bags there is no problem. Stratified seeds should be kept at about 40 °F, but in most cases a variation of four or five degrees is not serious. Actual freezing does not help the after-ripening process except in a few cases. Examine the seeds from time to time after they have been in stratification and as soon as any show signs of germinating all should be removed from the cold and planted.

Fringe-tree, many viburnums, and peonies have a type of dormancy called epicotyl or shoot dormancy. The seeds germinate and roots appear after a warm treatment, but the shoots fail to develop until they have been exposed to a temperature of about 40 °F for several months. In other seeds there is a combination of factors inhibiting germination, and dormancy can be overcome only by combined treatments.

Seeds Having Special Requirements for Germination

Germination of many seeds is delayed because they have hard seed coats; the condition is particularly common among members of the Legume Family. Scarification of seed coats will greatly hasten germination. The following are a few of the woody plants having such seed coats:

Camellia spp.
Caragana arborescens, Siberian peashrub (soak in water 12 hrs.)
Cercis canadensis, redbud*
Cladrastis lutea, yellowwood
Cornus florida, dogwood*
Cotoneaster spp.*
Crataegus mollis, redhaw*
Gleditsia triacanthos, honey locust
Gymnocladus dioica, Kentucky coffeetree
Ilex aquifolia, English holly*
Ilex opaca, American holly*
Koelreuteria paniculata, golden raintree
Paeonia suffruticosa, tree peony
Robinia pseudoacacia, black locust
Rosa blanda, meadow rose*

Other seeds require surprisingly low temperatures, not just for after-ripening, but for germination. Examples:

Calochortus macrocarpus, mariposa lily, only below 41 °F
Delphinium, annual delphinium, best below 68 °F
Lewisia rediviva, bitter-root, only below 50 °F
Lonicera tatarica, tatarian honeysuckle, and *Aquilegia canadensis,* American columbine, best in temperatures alternating from 50° to 77 °F
Viola tricolor, pansy, only below 70 °F

Most seeds germinate equally well in light or darkness, but some perform better in light.

Stimulated by light:
Draba aizoides
Epigaea repens, trailing arbutus
Gentiana septemfida, crested gentian
Mimulus guttatus, monkey-flower
Primula denticulata, Himalayan primrose

Require light:
Ageratum
Begonia
Browallia
Calceolaria
Coleus
Exacum
Gloxinia
Helichrysum, strawflower
Impatiens
Lactuca sativa, lettuce
Matricaria, matricary
Nicotiana, flowering tobacco
Petunia
Primula malacoides, fairy primrose
P. obconica, top primrose
Ramonda myconi, rosette ramonda
Salvia, red salvia (not blue)

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*Also has immature embryo, will need stratification, or autumn sowing.

FERN PROPAGATION FROM SPORES

Charles T. Gleaves

Here's how to propagate ferns from spores. A quick reading of a text outlining the fern life cycle would be a very helpful first step. (Most encyclopedias will suffice.) The next step is to obtain spores. When collecting from a living plant, clip a small piece of a fertile frond, place the frond with the spore side down in the middle of a sheet of paper and fold the paper around it. Wait a day or two for the spores to drop onto the paper, then carefully open the paper and remove the frond. Gently tap the dustlike spores to one side of the paper. Large objects such as spore cases will slide down the paper faster. Discard.

The next step is to provide a sterile growing medium on which to sow spores. Sterility is essential for success. Moss, fungi, blue-green algae, and green algae are all aggressive competitors that can ruin a young crop of fern gametophytes. (Gametophytes are the tiny, flat plants that grow from spores.) Once the medium is sterilized it must be kept sterile for at least several weeks. It is best to maintain sterility at least until sporophytes begin to appear. (Sporophytes are the offspring of the gametophytes and the final object of our attention.) This could be for as short a time as a few months or as long as a year in unusual cases.

For a growing medium I use a fine-textured mix consisting mostly of Canadian peat moss. The exact composition is not critical for most species. For a container I use a Petri dish. If you don't have Petri dishes, any shallow, clear container can be used. A clear glass or clear plastic party cup covered with plastic wrap will work.

How To Sterilize

An easy sterilization technique involves heating the soil and container in a microwave oven. Fill the container half full with the soil and cover with the glass lid or plastic wrap. Secure the plastic wrap with a rubber band. Heat the soil twice at a moderate speed to assure thorough sterilization, making sure not to bubble the soil. If a plastic container is used, avoid excessive heating; the plastic may become misshapen.

When the dishes are cool, carefully lift the lid, quickly sprinkle spores into the dish and replace the lid. Do this as fast as possible to avoid contamination.

The containers should be placed under, and 5 to 10 inches away from, fluorescent lights. A windowsill might substitute, but avoiding direct sunlight and yet getting enough light is difficult.

The soil with the spores should be moist but not wet; remember there is no drainage in these containers. With the lids in place the soil will stay moist for a month or more, but when it does begin to dry, use sterile water. This is important! I use the microwave oven to boil water in a container with an eye dropper top screwed on loosely to let steam escape. The eye dropper is a good watering tool.

When the sporophytes emerge in a few months (or longer) they should be plucked out with a pencil tip and put into another container. A clear plastic party cup with a hole in the bottom and polyethylene plastic wrap (*e.g.*, Glad Wrap) makes an excellent second stage container. Put a couple of inches of soil in the bottom of the cup and moisten it. Sterilization is optional. The ferns are large enough to effectively compete with most contaminants. Place three small sporophytes with their associated gametophytes into the cup and cover. Under fluorescent lights most ferns will grow to a few inches in height over a period of three or four months. (A few species need a slightly less humid environment.)

When the sporophytes reach an inch or two in height, remove them from the cups and plant into clay or plastic pots. Empty the used plastic cups and invert them over the newly potted sporophyte for a week or two to provide a transition period from the highly humid plastic-covered cup to the relatively dry open air of the growing bench.

At this point propagation is over and general cultivation begins.

MULTIPLICATION BY DIVISION

William I.P. Campbell and Alan D. Cook

Division is simply cutting or breaking a plant crown, or clump of suckers or aggregation of tubers, corms or bulbs, into segments that are planted and grown into new plants identical to the parent. With no special structures or equipment and very little effort, a gardener can divide certain plants for modest increases.

Dividing Perennials

To keep most perennials vigorous, they should be divided periodically, discarding the older center growth and replanting only the strong growth from the outer edge of the clump. An easy way to divide a plant is to lift it, then insert two spading forks back-to-back into the clump (see p. 23) and bring the fork handles together, prying the clump apart. This technique reduces damage to roots.

Clumps that are firmly massed (such as ornamental grasses, phlox or rhubarb) may not respond to the two-fork method (for that matter, how many of us have two spading forks?). A shovel or spade, or even a hatchet, may be wielded vigorously to chop such clumps into squares (like hunks of sod) which when planted usually respond as rewardingly as gently-teased segments from more fragile clumps.

Less drastic division involves modest excavation and removal of peripheral segments while leaving the parent plant in its original spot. This works well with plants that form multiple crowns (such as hosta) and with those that respond poorly to total disturbance.

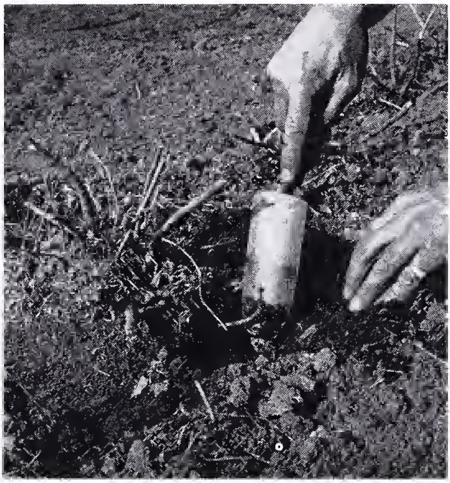
Divisions can be made at various times of the year, but a good rule to follow is to divide fall-flowering plants in the spring, and spring-flowering plants in the fall. Some perennials—chrysanthemums are an example—should be divided every year; others, among which are *Helenium,* aster, *Monarda* and *Oenothera,* every two or three years. Many, such as phlox, iris, daylily, *Physostegia* and astilbe, should be divided only every three or four years. Finally, there are some that do not take kindly to being disturbed and so should be left alone unless the plant becomes weak and flowers sparsely; these include peony, gas plant (*Dictamnus*), bleeding-heart (*Dicentra spectabilis*), Oriental poppy (*Papaver orientale*), lupine (*Lupinus polyphyllus*), Christmas-rose (*Helleborus niger*), butterfly weed (*Asclepias tuberosa*), false indigo (*Baptisia australis*), and sea-lavender (*Limonium latifolium*).

For perennials amenable to division, refer to the perennial propagation list, p. 28.

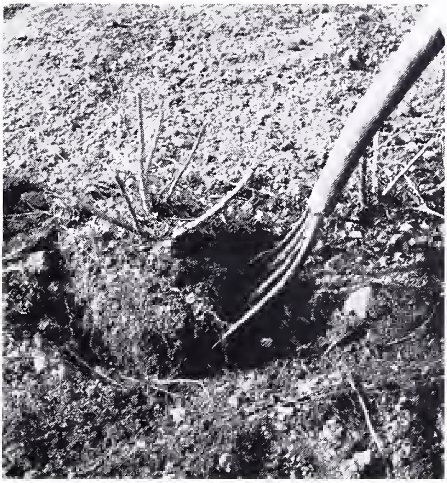
Multiplying Bulbous Perennials

Spring-flowering bulbs, which are also perennials, are usually increased by removing the small bulbs or offsets that form at the bases of the mother bulbs and growing them in rich light soil for two or three years. If tulips and narcissi are to be propagated this way they should be planted quite shallow; this will lead to the production of more offsets. Hyacinths can be induced to produce a large number of bulblets if the base of the mother bulb is scooped out or if it is scored with several diagonal cuts reaching about half way through the bulb. The operation is done in August and the treated bulbs are placed where it is light, warm and dry until October or November, when numerous small bulblets will have formed along the wounds. The whole cluster, old bulb and all, is planted about 5 inches deep. The following summer the young bulbs can be dug and separated, then replanted in the fall. It requires two to five years for young bulbs to reach the flowering stage by these methods.

Lilies can be propagated in several ways. Many can be grown from seed, others from bulbils that form on the stems in the axils of

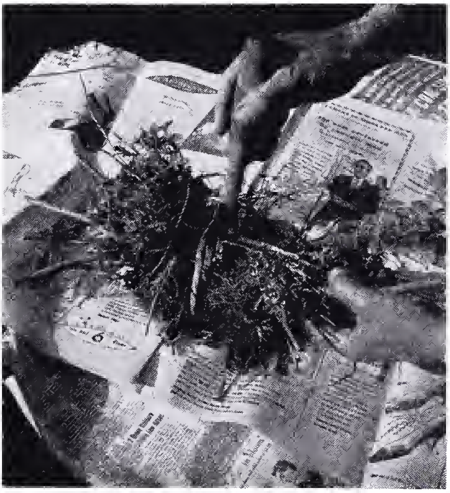


Propagating by division. First step is to remove topsoil from around plant.

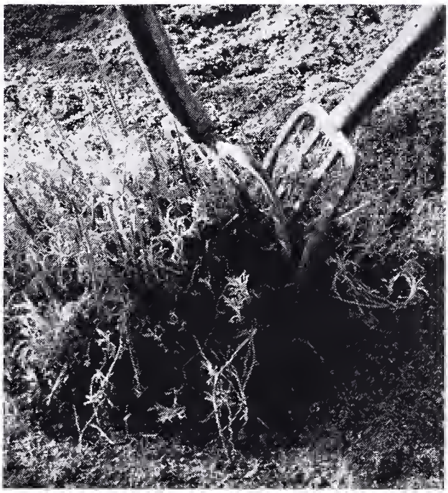


Plant is carefully lifted with fork.

Photos by H. Gantner



Dividing plant with hand fork.



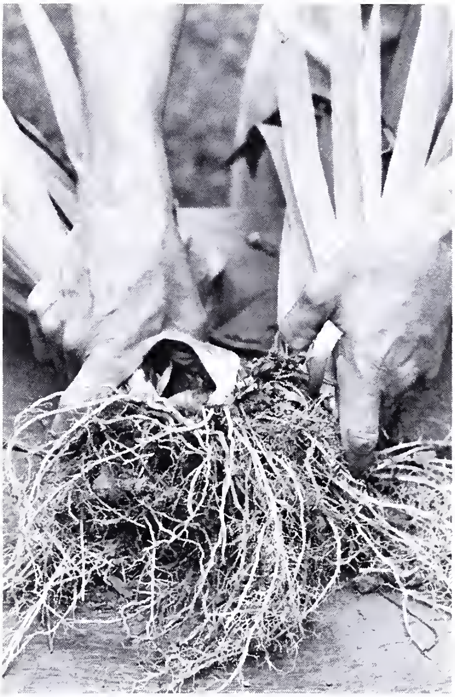
Alternate method of dividing plant using two garden forks back to back. Bringing handles of forks together separates parts of plant with minimum damage.

the leaves. Some form such bulbils on the underground portions of the stem. The bulbs of many lilies are formed of scales which furnish another method of propagation. The scales are detached, dusted with a fungicide and then placed in a warm propagating medium where bulblets will form at their bases. The time required for growing flowering-size plants in this way varies from one to four years depending on the species.

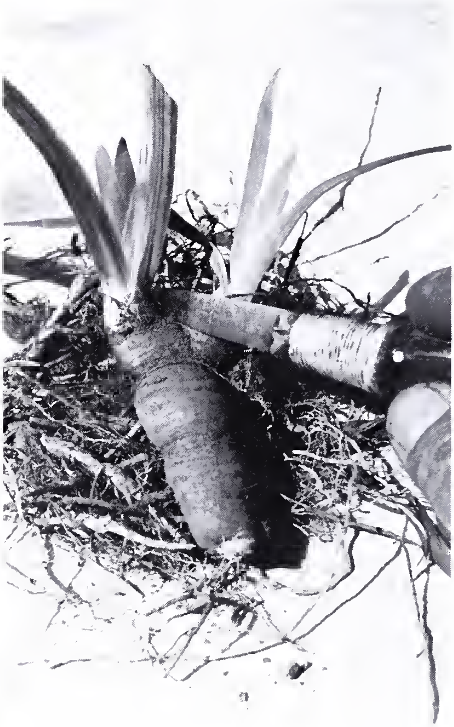
Dividing Shrubs

A number of shrubs form crowns or clumps and can be divided, preferably in early spring while dormant, or in autumn where winters are mild. Segments with rooted stems may be chopped loose with a spade, or more gently excavated and excised with pruning shears or pruning saw. In the latter method, care should be taken to avoid dulling of cutting edges by contact with soil.

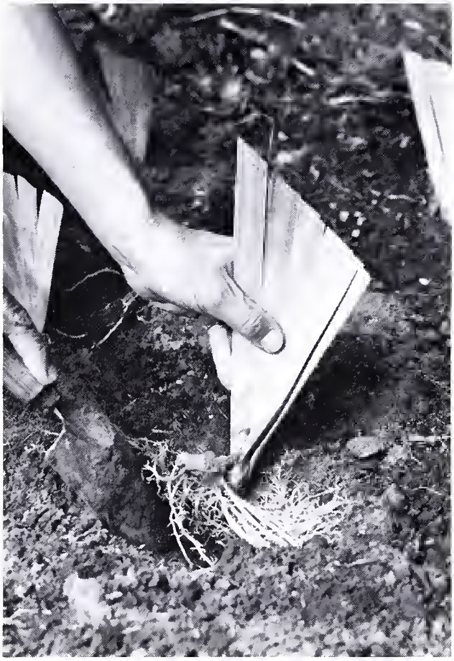
Photos by H. Gantner



After digging iris, shake soil off clump, separate plants by hand. Check rhizomes for borers or rot.

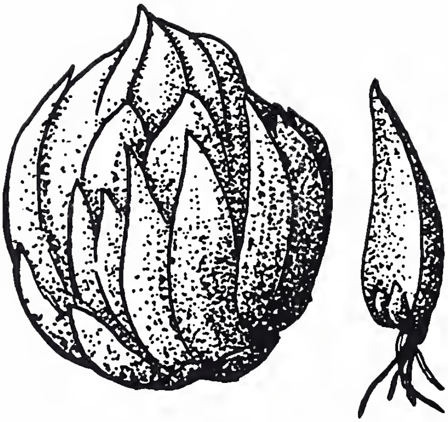


Use knife to divide iris rhizomes.

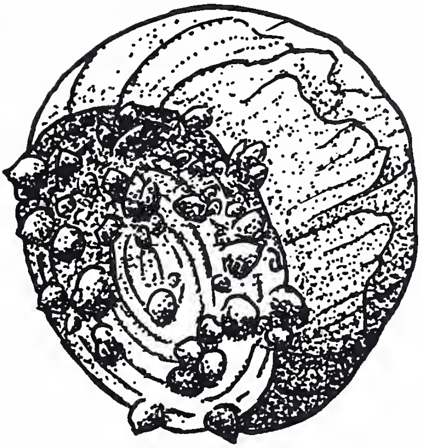


Trim tops of iris. Plant divisions at same depth as they were growing before digging.

Drawings by Peter K. Nelson



Lily bulb and detached scale showing buds and roots.



Numerous bulblets will form on a hyacinth bulb after it is hollowed out.

Entire shrubs with a reasonable root mass can be dug and cut into segments by one means or another and immediately replanted.

Division is seldom a worthwhile practice if shrubs are relatively young. After a number of years in one location, however, the following species may build up divisible crowns or clumps:

Aesculus parviflora (bottlebrush buckeye)
Aralia spp. (devil's walking stick)
Aronia spp. (chokeberry)
Berberis spp. (barberry)
Clerodendron spp. (glory-bower)
Clethra spp. (summersweet)
Cornus spp. (shrubby dogwoods)
Deutzia spp.
Euonymus spp.
Gaultheria spp. (wintergreen)
Hydrangea spp.
Hypericum calycinum (St. Johnswort)
Indigofera spp. (indigo)
Itea virginica
Kerria spp.
Lespedeza spp. (bush-clover)
Leucothoe spp.
Mahonia spp. (holly-grape)
Neviusia alabamensis (snow-wreath)
Paxistima spp. (pachistima)
Pachysandra spp.
Polygonum spp. (knotweed)
Potentilla fruticosa (bush cinquefoil)
Rhododendron spp. (some azaleas)
Rhus spp. (sumac)
Rosa spp. (some shrubby roses)
Rubus spp. (bramble fruits)
Spiraea spp. (spirea)
Symphoricarpos spp. (coralberry, snowberry)
Syringa spp. (lilac)
Vaccinium spp. (blueberry, cranberry)
Xanthorhiza simplicissima (yellowroot)

PERENNIAL PROPAGATION

Steven M. Still

Herbaceous perennials, dependable in form, texture and color, come up from the same root system year after year. Another advantage of this plant group is ease of propagation by the home gardener. No wonder at their renewed popularity.

There are several reasons for the interest in propagating perennials. Plants can be increased with little expense and relatively little effort. A homeowner can acquire plants (from friends, public gardens or elsewhere) that may be unavailable through commercial sources. And propagating is enjoyable and gratifying. There is something inherently pleasing about taking seeds or cuttings from a single plant and ending up with a limitless number of new plants.

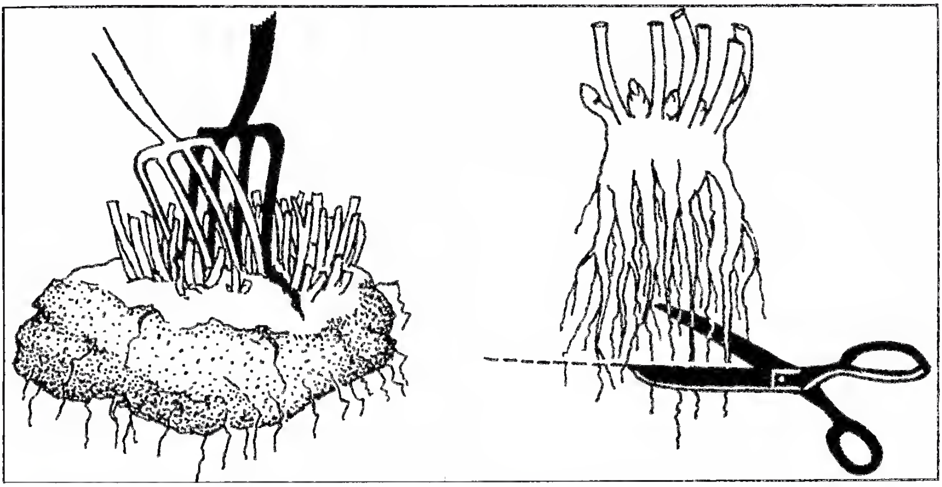
Most perennials can be propagated by more than one method. Propagation may be sexual (in which case seeds are used, see p. 9) or asexual (including division, stem cuttings and root cuttings).

Division

Division has always been a simple reliable method of propagating perennials, not requiring any special facilities or equipment. If there is a disadvantage to this method, it would be that it is inefficient in terms of the rate of increase.

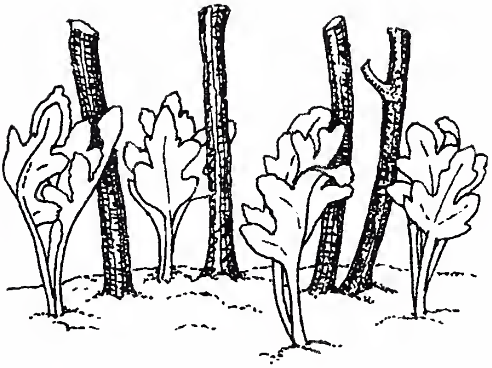
With division the main consideration is timing. Some, such as iris and peony, require very specific times. The general advice, however, is to divide fall-flowering perennials in the spring and spring-flowering perennials in the autumn. If plants are transplanted in autumn it should be done in time for the plants to become well established before winter. They should be of good size and mulched well for the winter because they are more susceptible to heaving. If one lives in areas of severe winters, division and replanting should occur almost exclusively in spring.

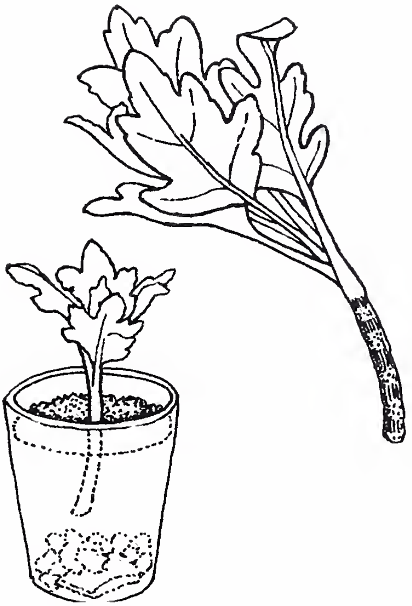
Some perennials, such as shasta daisy, require dividing every year; others, such as beebalm and sneezeweed, every two or three years. Many, such as daylily, Maltese cross and bearded iris, should be divided every three or four years. Finally, there are some that should be disturbed as little as possible, including butterfly weed, false indigo, balloon-flower, sea-lavender, peony, and gas plant.



Drawings by Eva Melady

These propagation steps are used for many perennials, including daylilies and Siberian iris. After trimming roots, the plant is divided by hand or with a knife, or even an axe if especially woody.





Chrysanthemums need garden renewal every year or two. Some growers like to propagate them by rooting cuttings from new shoots in spring, others prefer to divide plants, resetting only the vigorous offsets.

Cuttings

Some perennials don't produce seed or don't come true from seed, and are also not suitable for division. To propagate them stem or root cuttings are often used.

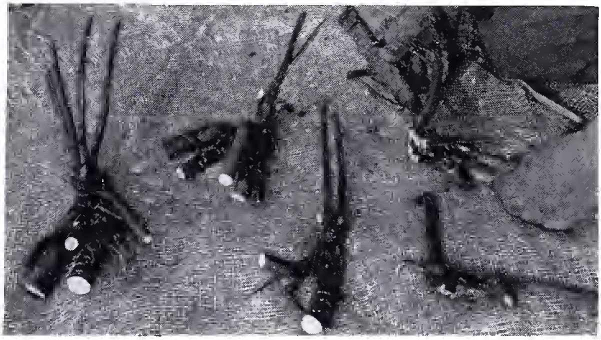
Spring-flowering plants produce the best stem cuttings in midsummer when growth that developed after flowering has hardened off. Cuttings from summer and fall flowering perennials should be taken in late spring. See pp. 36, 45 and 46.

Some perennials are more easily propagated by root cuttings which may be taken from plants dug in the autumn when the roots have stored the most carbohydrates, but spring and even summer root cuttings are used. Two species commonly propagated by root cuttings are garden phlox and oriental poppy. See p. 51.

Multiplying Bulbous Perennials

Spring-flowering bulbs are usually increased by removing the small bulbs or offsets that form at the bases of the mother bulbs. Tulips and daffodils are two examples of bulbs that can be propagated in this manner.

Loose-scaled bulbs, such as garden lily, can be propagated in several ways. The scale of the garden lily can be detached, dusted with a fungicide and placed in a propagation medium where bulblets will form at the base of the scale. Lilies can also be propagated by seed or from bulbils that form on the stems in the leaf axils. Propagation of bulbous plants by seeds has the same disadvantage as with other perennials in that it will take three or four years before the plant will flower. ❧



H. Gantner

Making divisions of peony roots; for best results each division should have three to five eyes.

PERENNIAL PROPAGATION

Scientific name/ Common name	Sow seeds	Time until flowers	Cuttings stem/root	When to divide	Notes
Achillea filipendulina fernleaf yarrow	spring	1 year		spring	
Aconitum napellus garden monkshood	fall	2–3 years		sparingly	or stratify moist & cold at least 6 weeks
Aegopodium podagraria 'Variegatum', variegated bishop's goutweed				spring or fall	
Alcea rosea hollyhock	July or August	next season			home-collected seeds may not come true
Allium spp. ornamental onion, chives, leek	after ripening	2–3 years			offsets or bulblets in fall
Anemone pulsatilla pasqueflower	early fall or early spring	18 months		older plants in spring	sow seeds shallowly
Anthemis tinctoria golden marguerite	spring		s/spring	spring or early fall	seeds may not come true
Aquilegia hybrids columbine	in greenhouse after refrigeration for 3 weeks – Do not cover seeds – Seeds outside in April			spring or fall	
Arabis caucasica rock cress	spring		s/following bloom	spring or fall	
Armeria maritima sea pink	collect seed in August, soak several hrs. before planting		s/in July or August (difficult)	spring or fall	seeds may not come true
Artemisia schmidtiana 'Silver Mound' wormwood			s/in spring	spring	
Asarum europaeum European wild ginger				spring	divide established clumps
Asclepias tuberosa butterfly weed	spring (germ. often poor)	2 years	s/early spring before growth		plant has a taproot so it shouldn't be disturbed after established

Aster novi-belgii New York aster				spring or fall	
Astilbe x *arendsii* astilbe	spring	2 years		spring when 1″ tall	
Aubrieta deltoidea false rockcress	spring	next season	s/in mid summer	spring	
Aurinia saxatilis basket-of-gold	August		s/June	spring	
Baptisia australis false indigo	soak seeds in water for 48 hrs. before planting in spring	2–3 years		spring	difficult to divide, taproot
Belamcanda chinensis blackberry lily		next season		spring	
Bergenia cordifolia heartleaf bergenia	spring			spring or fall	
Campanula spp. Canterbury bells, bellflowers	late spring		s/spring	spring or early fall	biennial Canterbury bells (*C. medium*) must be started from seed each year; plant in July/August
Centaurea montana mountain bluet	spring		s/Sept. in hotbed or greenhouse	spring or fall	
Cerastium tomentosum snow-in-summer	spring or late summer		s/early summer	spring or fall	take care to prevent root damage
Chrysanthemum spp. & hybrids chrysanthemum	spring		s/spring of hardy chrysanthemum	early spring or late summer	cultivars don't come true
Convallaria majalis lily-of-the-valley				spring	
Cortaderia selloana pampas grass				spring	
Crocus hybrids crocus				dig clumps every 3 yrs. in late June or early Sept.	detach new corms from mother

PERENNIAL PROPAGATION – Continued

Scientific name/ Common name	Sow seeds	Time until flowers	Cuttings stem/root	When to divide	Notes
Delphinium elatum delphinium	fresh seeds in August		s/spring	early spring	
Dianthus spp. sweet-william, pinks, carnations		2nd year	cuttings or layering midsummer (maiden pink & cottage pink)	spring	
Dicentra spp.	August or September		r/3″ long after flowering	spring	
Dictamnus albus gas plant	spring (stratified for 6 wks.) or fall			possible but hard	
Digitalis purpurea common foxglove	August	the next summer		spring	
Echinacea purpurea purple coneflower		2 + years	r/early spring	spring	seeds do not come true
Echinops exaltatus globe thistle			r/2″–3″ long in fall in sand cold frame	spring	transplant in spring
Epimedium spp. barrenwort				rhizomes in spring or fall	
Eranthis hyemalis winter aconite	June & July	3–4 years		tubers in late summer	
Erigeron speciosus Oregon fleabane	spring	1st or 2nd season		spring or fall	
Eryngium amethystinum sea-holly	when ripe		r/spring		division difficult because of taproot
Euphorbia spp. spurge	fall or early spring				divide carefully, fleshy roots
Festuca ovina var. *glauca* blue fescue	spring			spring or fall	
Fritillaria imperialis crown imperial		4–6 years		divide bulbs after flowering	
Gaillardia x *grandiflora* blanket flower	spring	same year	s/August or September	spring	cuttings need winter protection

Galanthus nivalis common snowdrop				divide bulbs after flowering	
Galium odoratum sweet-woodruff				spring	
Geranium spp. crane's-bill	species from seed–spring			spring	
Geum hybrids geum				spring	
Gypsophila paniculata baby's-breath	April		s/May	spring or fall (difficult)	cultivars are grafted onto seedling rootstocks
Helenium autumnale sneezeweed	spring	sparsely 1st year		spring	
Heliopsis helianthoides sunflower, heliopsis		2 years		spring or fall	
Helleborus niger Christmas-rose	June or July (when ripe)	2–3 years		spring	division is risky
Hemerocallis spp. daylily		2–3 years		early fall–sections w/3 shoots	large clump division is risky
Heuchera sanguinea coralbells	spring	1 year	leaf/midsummer	spring or fall	use leaf plus a short segment of stem for cuttings
Hibiscus moscheutos rose-mallow	spring or fall			spring	
Hosta spp. hosta, plantain-lily	seeds after they ripen			spring	variegated forms don't come true from seed
Hyancinthus orientalis Dutch hyacinth		2–3 years		offsets from old bulbs	
Iberis sempervirens evergreen candy-tuft	spring or fall		s/2" long from non-flowering shoots between June & August	spring	
Iris hybrids bearded, Japanese, Siberian iris				rhizomes in July & August	separate into segments w/one set of leaves & several seeding roots

PERENNIAL PROPAGATION – Continued

Scientific name/ Common name	Sow seeds	Time until flowers	Cuttings stem/root	When to divide	Notes
Kniphofia uvaria red-hot poker	spring	2–3 years		spring	
Lavandula angustifolia true lavender	spring		s/from side shoots in August		
Liatris spicata spike gayfeather	spring	by 2nd year		cultivars by spring division	
Lilium spp. garden lily	varies	several years		divide bulb scales	aerial bulblets in fall, difficult from seed
Limonium latifolium sea-lavender	spring or fall	3–4 years	r or s/February & March in cold frame in sand	early spring	
Linum perenne perennial flax	spring	flower 2nd summer	2″ cuttings of basal shoots	late spring	doesn't divide well
Liriope spicata creeping lilyturf				spring	
Lobelia cardinalis cardinal flower	fall or spring			dig basal offsets in fall	
Lupinus spp. lupine	late summer, transplant in spring		s/with a small piece of root or crown in early spring	early spring	
Lychnis chalcedonica Maltese cross	April except double-flowering types			spring or fall	
Lycoris squamigera magic lily				dig bulbs after foliage dies in midsummer; remove offsets	plant offsets immediately
Lysimachia nummularia moneywort	spring		spring	spring	
Mertensia virginiana Virginia bluebells	spring or fall			August, September	

Monarda didyma bee-balm	spring	vary		division in early spring	
Narcissus spp. & hybrids daffodil				divide dormant bulbs	divide after foliage has died
Oenothera missourensis sundrops	spring or fall		s/late summer	early fall	
Paeonia lactiflora Chinese peony		5–7 years		cut large clumps in sections of 3–5 buds, set 1″ below soil surface in Aug./Sept.	tree peony is grafted onto 4–6″ roots of *P. lactiflora*
Papaver orientale Oriental poppy	after ripening		4–6″ root cuttings in mid-to-late summer	clumps in midsummer	cultivars don't come true
Phalaris arundinacea var. *picta* ribbon-grass				clumps in spring—plant outer sections	
Phlox paniculata summer phlox			r/fall	spring or fall	2″ lengths upright in sandy soil in cold frame or greenhouse
Physostegia virginiana false dragonhead				clumps in spring or fall	seeds will show variations
Platycodon grandiflorus balloon-flower	spring	2 years		spring	
Polemonium caeruleum Jacob's-ladder	spring		s/midsummer	clumps in mid- to late summer	flower color will vary from seed
Polygonatum biflorum Solomon's seal				spring	
Primula x *polyantha* primrose	sow seeds as soon as ripe or stratify & sow in spring			spring or fall	
Pulmonaria saccharata Bethlehem-sage	spring			fall	water often to establish before winter

PERENNIAL PROPAGATION – Continued

Scientific name/ Common name	Sow seeds	Time until flowers	Cuttings stem/root	When to divide	Notes
Rudbeckia hirta var. *pulcherrima* black-eyed susan	March & April	during the season		clumps in spring	
Saponaria ocymoides rock soapwort	spring or early fall		s/mid-summer	early spring	
Scabiosa caucasica pincushion-flower	spring or late summer			spring	
Scilla siberica Siberian squill				late summer	lift clumps & divide bulbs
Sedum spectabile showy stonecrop-sedum	spring		s/spring or summer	early spring	
Sempervivum tectorum hen-and-chicks				separate small outer rosettes from mother	
Stachys byzantina lamb's-ear	spring			spring	
Thalictrum rochebrunianum lavender-mist meadowrue	late summer or autumn			spring or fall	provide winter protection
Tiarella cordifolia Allegheny foamflower				clumps in spring	
Tradescantia virginiana spiderwort	spring or summer	the following summer		spring	
Trollius europaeus globeflower	summer	flowers the next year		spring or summer	not needed for 5 yrs. or more
Tulipa spp. & hybrids tulips				divide bulbs	
Veronica spicata spike-speedwell	spring		s/early summer	spring & fall	variations will occur from seed
Viola spp. sweet violet, viola	summer	the next summer		clumps in spring or early summer	provide winter protection

An easy, widely-practiced method of propagating woody plants...

ROOTING SOFTWOOD CUTTINGS

Alan D. Cook

Propagation by means of softwood cuttings is a simple method of multiplying many kinds of trees and shrubs. Softwood cuttings are made from the current season's growth with nearly mature foliage. With proper treatment and modern techniques, such as the use of root-inducing hormones, softwood cuttings of many woody plants formerly propagated only by grafting can now be successfully rooted. Typical examples are magnolia (*Magnolia* spp.), Asiatic maples (e.g. *Acer japonicum, A. palmatum*), and pink flowering dogwood (*Cornus florida rubra*).

When To Take Cuttings

There are no hard and fast rules as to when softwood cuttings should be taken, but in general, cuttings of deciduous plants (those which lose their leaves in winter) are taken in late spring and summer, those of broad-leaved evergreens in summer.

For many easy-to-root species, timing is relatively unimportant. A good general rule for difficult subjects is to take cuttings when the shoots will snap when bent.

Early morning is the ideal time to take cuttings. Terminal portions of growth, whether leaders or side shoots, are best. A long shoot of an easy-to-root species may be cut into several cuttings. Discard any infested with disease or insects.

Make cuttings 2 to 6 inches long, depending on the variety and available shoots. Make basal cuts about ¼" below a node. Keep cuttings uniform in length. Short cuttings can be shaded out by taller ones.

Cuttings must not be subjected to desiccation. Cut a small handful and place immediately in a plastic bag or in damp burlap; keep them shaded. Small lots can be put immediately in a bucket of water.

Sharp pruning shears may be used for collecting cuttings, but an experienced propagator can cut faster and more cleanly with a sharp grafting knife.

Cuttings of some plants, such as *Cytisus, Corylopsis* and *Coronilla,* are found to root better if side shoots are taken with a slight "heel." This is done by tearing the cuttings from the parent plant with a downward pull taking a bit of the larger trunk's tissue.

In a cool shaded place, prepare cuttings for sticking. The more leaves, the faster and better a cutting can root, and some propagators do not remove bottom leaves. However, treatment with hormone powder and sticking in rooting medium are easier if the basal leaves are removed. With most cuttings, removal is by pulling the cutting with one hand through thumb and forefinger of the other. This often causes some wounding which may be beneficial. With soft cuttings, it may cause breakage of stems and damage to lower buds (which may be desirable for producing bushy plants). To prevent excessive damage, pick leaves off one at a time with fingers, or cut them with knife or shears. Remaining leaves, if they are large and space is limited, may be cut back up to one half, but some plant vigor will be sacrificed.

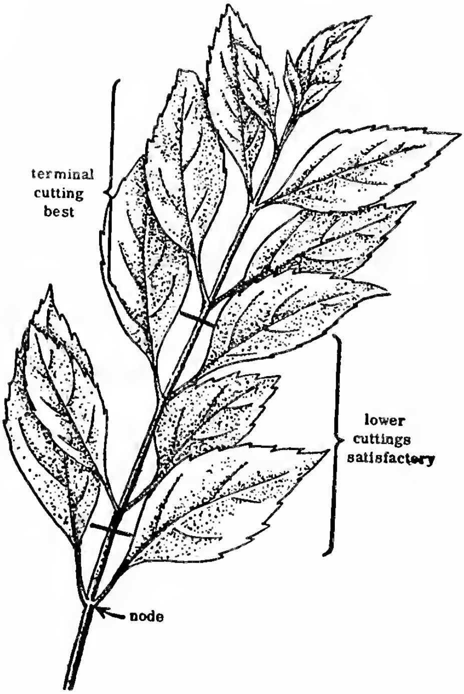
An approved practice with many plants (rhododendrons, maples, magnolias and deciduous azaleas) is to wound the base of the cutting before applying the hormone. Draw a sharp knife down the side of the stem for a distance of one or two inches above the base end to expose the active tissue (cambium) beneath the bark. Some propagators terminate the wound about ¼" from the cutting base to reduce possibility of decay.

As fast as the cuttings are prepared, place between moist paper or cloth, or in a polyethylene bag. They should be planted without delay but, if necessary, they may be put into a plastic bag and stored in a refrigerator.

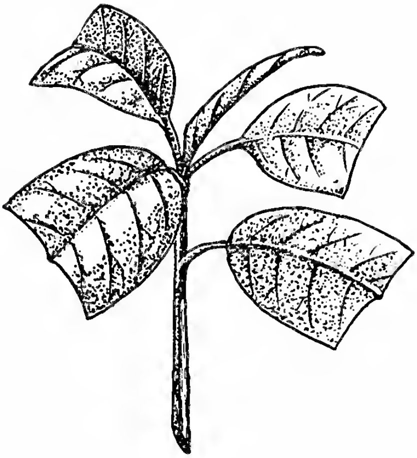
Root-Promoting Hormones

Hormones to induce the growth of roots on cuttings are available under several trade names. (See p. 50.) In general, powders are the best for amateur use. Follow the manu-

Drawings by Peter K. Nelson

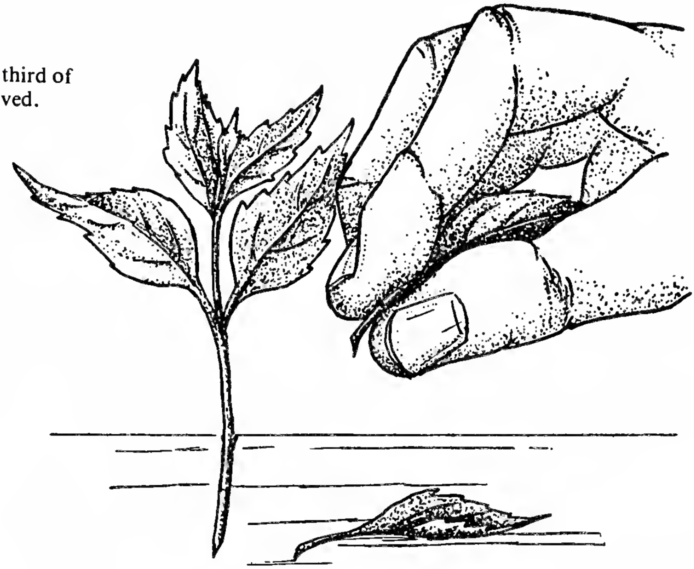


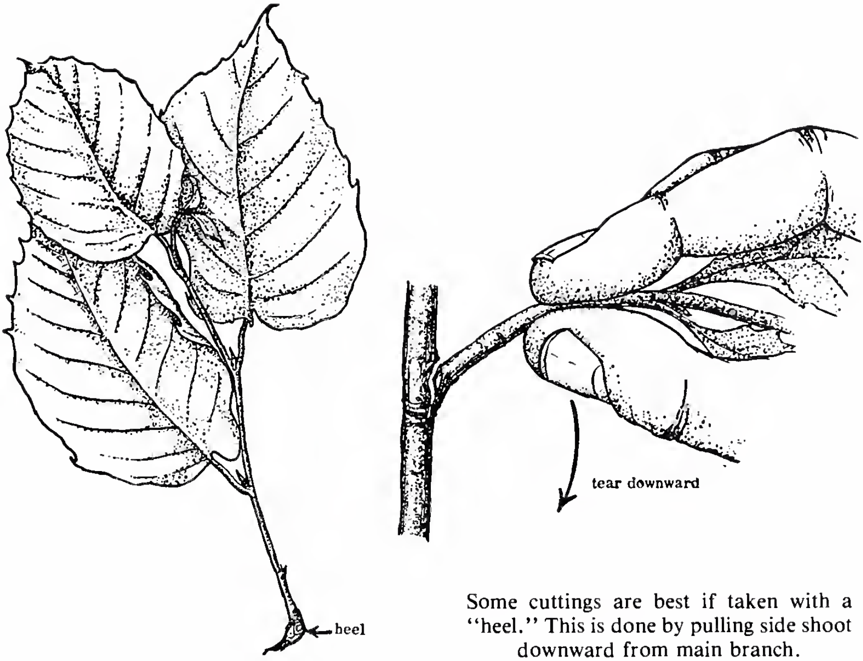
Terminal sections are best for softwood cuttings but long shoots can be cut into several sections.



Large leaves can be clipped to about half size to allow more cuttings per unit of area and to reduce surfaces from which the cuttings can lose excessive water.

The leaves on lower third of cutting are removed.



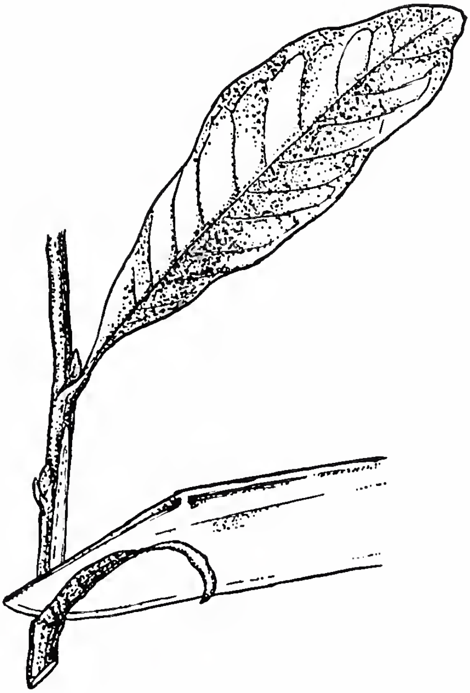


Some cuttings are best if taken with a "heel." This is done by pulling side shoot downward from main branch.

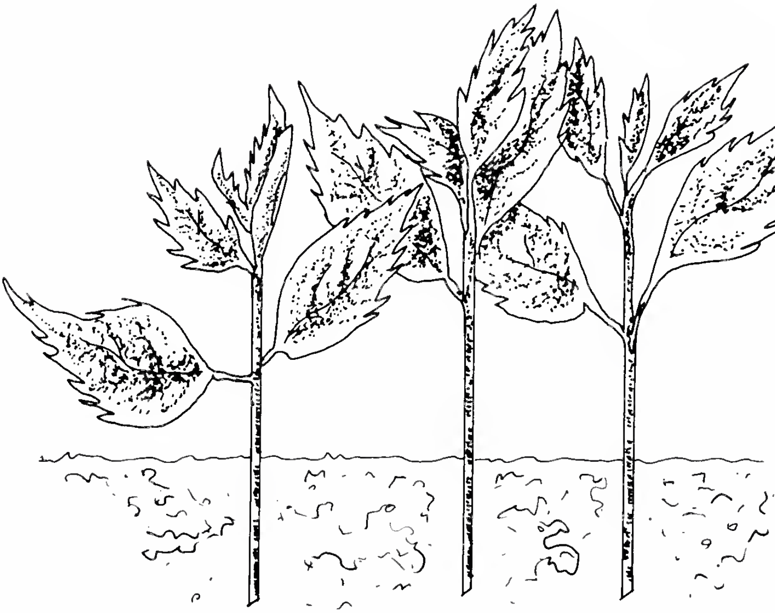
facturers' instructions. Remove only enough rooting material for the job at hand. Do not dip directly in the original packaging or return used hormone powder to package; you may contaminate both the package and subsequent cuttings. If instructions are unavailable, experiment by using a strong powder for a few cuttings, normal for some, and stick a few with no treatment. Keep records.

Rooting Media

The rooting medium (see p. 4) can be placed in small boxes or greenhouse flats, bulb pans or flower pots, plastic boxes, cold frames, or in specially prepared beds in shady spots out-of-doors. Recently developed aids to rooting cuttings are the use of plastic film (see p. 4) and mist (see pp. 45–7).



Before dipping in hormone powder, base of cutting may be "wounded" by cutting away a thin strip of bark.

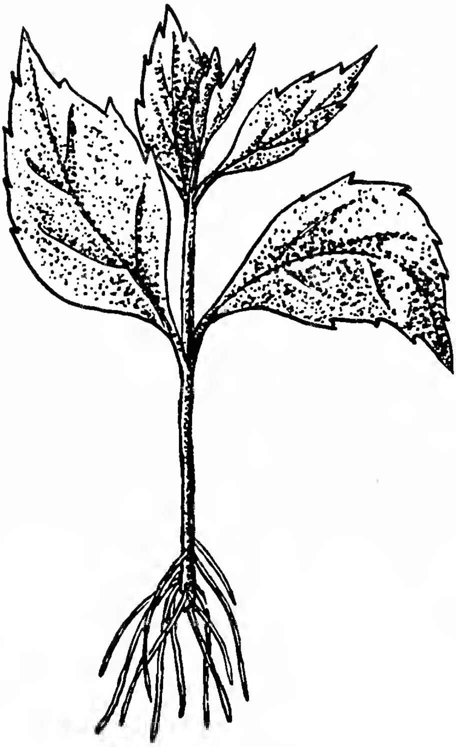


Cuttings are inserted into the medium to one fourth to one half their length.

Inserting the Cuttings

Before inserting the cuttings the medium should be copiously watered and allowed to drain. Insert cuttings to about ⅓ their length if they are to be placed where the humidity can be kept high, to about half their length if planted in the open. Insert just far enough apart to permit all leaves to receive light.

The long-established practice of firmly tamping the medium about the cuttings is no longer considered necessary. After inserting the cuttings, water again; this washes the particles closely about the bases of the cuttings. Mixtures containing peat moss should be watered only moderately, because peat absorbs a great deal of water and tends to remain too wet too long.



Rooted cutting ready for transplanting.

Care During Rooting

During rooting the medium must be kept uniformly moist, but never soggy. For the first 7 to 10 days the cuttings should be lightly shaded—with cheesecloth, whitewashed glass or covers of lath or netting. After cuttings are established, the shade can be gradually reduced. Many broad-leaved evergreens will root in partial shade; most deciduous plants need more light.

If cuttings are in closed containers, ventilate enough to prevent growth of fungi. After cuttings are rooted, the covering should be removed for increasing periods of time until finally left off entirely. Rooting under a mist system, if possible, is ideal. (See p. 45.)

By autumn many of the cuttings will be ready for planting directly in the ground. If they were rooted late in the season, they can be placed in a cold frame the first winter. When planting rooted cuttings directly from the rooting medium to outdoor beds, place 6 to 12 inches apart. When the plants begin to crowd, transplant. Cuttings placed directly in outdoor beds will need shading for a longer period than those grown in pots.

Some woody plants such as magnolias, maples, pink flowering dogwood and some viburnums are easy to root, but difficult to overwinter. The best solution is to root the cuttings as early as possible so that they are well established by winter. Place rooted cuttings where the temperature is just above freezing, but below 45 °F throughout the winter. Small quantities may be snugly wrapped in plastic and stored in the refrigerator. Another overwintering aid for such cuttings is to extend day length with supplemental illumination to 16 hours or more.

Candidates

Below is a list of some plants that can be propagated by softwood cuttings. Not all are easy, and some may be difficult to overwinter.

Abelia spp.
Acer campestre (hedge maple)
A. ginnala (Amur maple)
A. griseum (paperbark maple)
A. palmatum (Japanese maple)
A. rubrum (red maple)
A. saccharum (sugar maple)
Aronia spp. (chokeberry)
Azalea (*Rhododendron* spp.) (deciduous azaleas)
Berberis spp. (barberry)
Buddleia spp. (butterfly bush)
Callicarpa japonica (beautyberry)
Calycanthus floridus (Carolina allspice)
Camellia spp.
Caragana arborescens (Siberian pea shrub)
Caryopteris x *clandonensis* (bluebeard)
Cephalanthus occidentalis (buttonbush)
Clematis spp.
Clerodendron spp. (glorybower)
Clethra alnifolia (summersweet)
Colutea arborescens (bladder-senna)
Cornus spp. (dogwood)
Corylopsis spp., (winterhazel)
Cotoneaster spp.
Cyrilla racemiflora
Cytisus spp. (broom)
Deutzia spp.
Diervilla sessilifolia (bush-honeysuckle)
Eleagnus angustifolia (Russian olive)
E. umbellatus (autumn olive)
Enkianthus spp.
Euonymus fortunei (wintercreeper)
E. europaeus (spindle-tree)
Exochorda giraldii wilsonii (pearl-bush)
Forsythia spp.
Fothergilla spp.
Gardenia jasminoides (cape jasmine)
Gaultheria procumbens (wintergreen)
Genista spp. (woadwaxen)
Ginkgo biloba (maidenhair tree)
Halesia spp. (silverbell)
Hibiscus spp.
Hydrangea spp.
Hypericum spp. (St. Johnswort)
Iberis spp. (candytuft)
Ilex spp. (deciduous holly)
Indigofera spp. (indigo)
Itea virginica
Kerria japonica
Kolkwitzia amabilis (beauty bush)
Lagerstroemia indica (crape-myrtle)
Laurus nobilis (sweetbay)
Lavandula officinalis (true lavender)
Lespedeza spp. (bush clover)
Ligustrum spp. (privet)
Liquidambar styraciflua (sweetgum)
Lonicera spp. (honeysuckle)
Maclura pomifera (Osage orange)
Magnolia spp.
Mahonia spp.
Malus spp. (apple, crabapple, some species and varieties)
Metasequoia glyptostroboides (dawn redwood)
Myrica cerifera (wax-myrtle)
M. gale (sweet gale)
Neviusia alabamensis (snow-wreath)
Osmanthus spp.
Paxistima spp. (pachistima)

Pachysandra terminalis (Japanese spurge)
Parthenocissus quinquefolia (Virginia creeper)
P. tricuspidata (Boston ivy)
Paulownia tomentosa (empress tree)
Philadelphus spp. (mock-orange)
Photinia spp.
Physocarpus opulifolius (ninebark)
Platanus spp. (sycamore, plane tree)
Populus spp. (poplar)
Potentilla spp. (cinquefoil)
Prunus spp. (plum, cherry, flowering almond, sand cherry, cherry-laurel)
Pyracantha spp. (firethorn)
Quercus palustris (pin oak)
Rhododendron spp. (deciduous rhododendrons and azaleas)
Rhodotypos scandens (jetbead)
Rhus aromatica (fragrant sumac)
Rosa spp. (rose)
Salix spp. (willow)
Sambucus spp. (elderberry)
Sorbaria spp. (false spirea)
Spiraea spp. (spirea)
Stephanandra spp.
Styrax spp. (snowbell)
Symphoricarpos spp. (snowberry, coralberry, Indian currant)
Symplocos paniculata (Asiatic sweetleaf, sapphire-berry)
Syringa spp. and hybrids (lilac)
Tamarix spp. (tamarisk)
Ulmus spp. (elm)
Vaccinium spp. (blueberry, coralberry)
Viburnum spp.
Vinca minor (periwinkle, myrtle)
Vitex spp. (chaste-tree)
Weigela spp.
Wisteria spp.
Zenobia pulverulenta (dusty zenobia) ❧

Quick and easy method for many woody plants...

PROPAGATION FROM HARDWOOD CUTTINGS

Roy M. Nordine

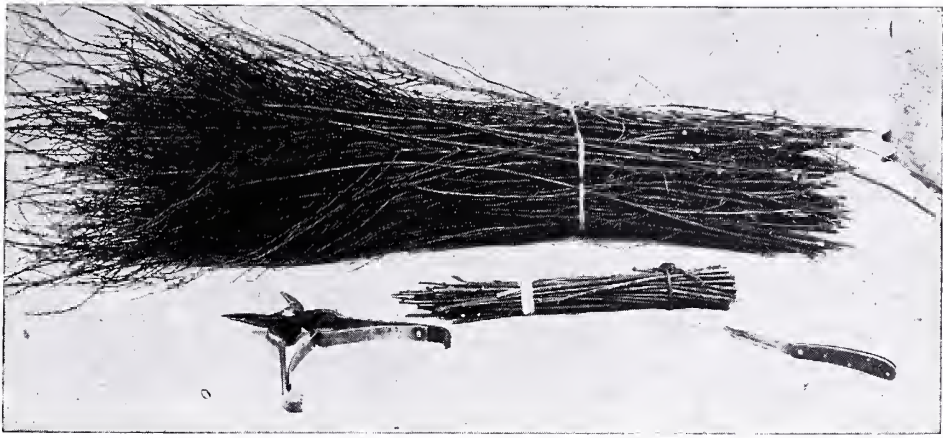
For propagation of woody plants from hardwood cuttings, the current season's growth is generally used, either the long canes that grew up from the base of the plant or the new growth on the ends of the branches. These canes or cuttings may be gathered soon after the dormant season has begun, or any time until late winter. Material from plants that may be injured by severe winter weather should be gathered before temperatures have dropped.

Storage

The canes may be made into cuttings at the time of gathering, or stored until later in a cool place (below 50°F, even at freezing temperatures). It is not necessary to bury them or to put the cut ends in moist material, but the canes should not at any time be subjected to drying conditions such as high or fluctuating temperatures, drying winds, or any circumstance that may draw the moisture from them. It is equally important to prevent excessive moisture near the stored material. The best way to store the canes is to bury them in a generous quantity of moist but not wet material, such as peat, sand, wood shavings, sawdust, sphagnum moss, or vermiculite.

Preparing Cuttings

Make cuttings 6 to 8 inches long with a knife or with pruning shears. Cut straight across or with a slight slant. Do not use very thin, weak canes or late growth at tips of


Photos by McFarland

Suitable branches for making hardwood cuttings, and bundles of cuttings ready for storage.

canes. The basal cut is unimportant except on plants with hollow stems or larger spongy pith, in which cases the basal cut is made just below a node (bud). The upper cut should be one-fourth inch or so above a bud whenever possible.

Gather the finished cuttings into bundles of convenient size. Tap the bottom of the bundle on a flat surface to level, label, and tie with cord or fine wire. Bury the bundles in sand, well-drained soil or suitable medium, either horizontally or vertically.

Planting

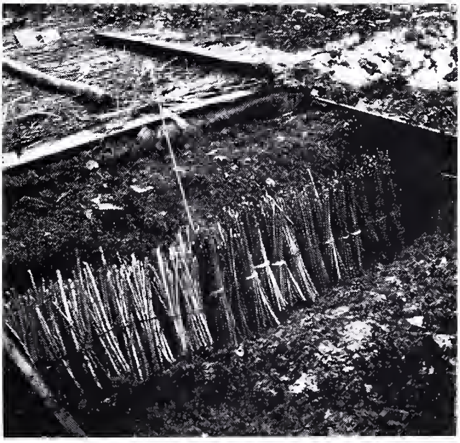
The cuttings should be placed in the ground as soon as the soil is workable. (Hormone treatment is not necessary.) Place them in full sun 9 inches apart, in rows 2 feet apart. Leave for two to three years. Or they may be set 6 inches apart, in rows a foot apart, and removed after one season. A tool such as a spade should be used to make an opening in the ground just wide enough to take the cutting and deep enough to place the top bud at the soil surface. Firm the soil around the cutting.

The percentage of cuttings that grow will vary considerably, depending on many circumstances; results of 80 percent are excellent.

[*Ed. note:* For small quantities of cuttings, wrap snugly in plastic and store in the back of the refrigerator until planting time. Or take, make, and stick hardwoods in autumn before soil freezes. Mulch with six to eight inches of loose straw to reduce heaving. Remove straw in early spring when growth begins. Or, with hardy types, wait until spring to take, make, and stick hardwood cuttings.]

The hardwood cutting technique may be applied to these:

Akebia quinata (five-leaf akebia)
Alnus (alder)
Amorpha (lead plant)
Callicarpa (beauty berry)
Campsis radicans (trumpet vine)
Caragana (pea shrub)
Caryopteris (bluebeard)


Bundles of hardwood cuttings ready to be buried for storage until spring.

Celastrus (bittersweet)
Colutea (bladder-senna)
Deutzia
Eleagnus angustifolia (Russian olive)
Euonymus—some species
Ficus carica (fig)
Forsythia
Gymnocladus (Kentucky coffeetree)
Hibiscus syriacus (rose-of-Sharon)
Hydrangea
Hypericum (St. Johnswort)
Kerria
Kolkwitzia (beauty bush)
Ligustrum (privet)
Lonicera (honeysuckle)
Lycium (matrimony vine)
Morus (mulberry)
Parthenocissus (Boston ivy and Virginia creeper)
Philadelphus (mock-orange)
Physocarpus (ninebark)
Populus (poplar)
Potentilla (cinquefoil)
Ribes (currant)
Rosa (rose)—some climbers and ramblers
Salix (willow)
Sambucus (elderberry)
Spiraea (spirea)
Symphoricarpos (Indian currant and snowberry)
Syringa persica (Persian lilac)
Tamarix (tamarisk)
Vitis (grape)
Weigela

Some Cutting Comments

Cuttings from young plants tend to root more easily than those from older plants. Cuttings from lower portions of plants and from water sprouts and suckers are more juvenile and tend to root faster and more easily. (Avoid understock suckers on grafted plants.)

As a rule, cuttings that have grown in sunshine root better than those that have been shaded. (Rhododendron cuttings are an exception.) Early morning, especially for softwood cuttings, is the best collection time.

Cuttings should remain in an upright position from the time of cutting until they are stuck. This allows the greatest translocation to the base of root-promoting chemicals within the cutting. Some operators put upright cuttings in plastic bags in a refrigerator for two days at 35–40°F before sticking.

Never make a second basal cut, lest you remove some of those translocated chemicals.

As insurance against drying, some propagators dip cuttings in an antidesiccant (Wilt-Pruf, Clearspray, etc.) before sticking. Others dip cuttings into pesticide solutions. A popular dip mixture is the insecticide Sevin and the fungicide Benlate (Benomyl) at manufacturers' recommended rates for spraying.

Cuttings from vertical stems, especially evergreens such as yew (*Taxus*) will grow into upright plants; cuttings from low side shoots will develop into bushy plants with spreading tendencies.

Unless it's the rainy season, for extra insurance, water stock plants copiously two days prior to collecting cuttings.

For cuttings dipped into rooting powder, make holes or a wide groove in the rooting medium large enough to accommodate cuttings without rubbing off the powder. Use a pencil, dowel, cleaver, etc. Firm medium (don't pack it vigorously) about the cutting bases.

For plants whose cuttings refuse to root with normal treatment, try:

(1) forced-growth cuttings (see p. 48).

(2) etiolation—a month prior to collection, wrap the basal portion of the intended cutting with black plastic electrical tape, then cut below the tape, remove tape, process the cutting.

(3) girdling—a month before taking cuttings, remove a ½" wide band of bark including cambium (scrape it off) at the base of each intended cutting. For an extra boost, make a petroleum jelly-rooting powder paste, apply to bark just above girdle, wrap with foil or plastic. After a month, cut in the girdled area and process the cutting.

Broadleaf and Narrowleaf Evergreens from Cuttings

If a plant doesn't drop current-season foliage in autumn, it's an evergreen. Some evergreens can be easily propagated by summer softwood cuttings (azaleas, pyracantha, camellia, evergreen euonymus), but most broadleaf evergreen cuttings are made during autumn (September, October and November in latitudes of New York and Columbus, Ohio), and narrowleaf evergreen cuttings generally root best if handled during November, December and January. Terminology for such cuttings rates a thesaurus section: firmwood, ripewood, intermediate, semi-hardwood, evergreen hardwood. The name doesn't matter; some other factors do.

Broadleaf Evergreens

Take cuttings in the morning from healthy stock plants, selecting fully mature terminal shoots 3-to-5-inches long (can be longer; will of course be shorter from dwarf varieties). Make cuts with sharp knife or pruning shears, and just below a node if convenient. Make cuttings of uniform length as you collect them because second basal cuts made in the work space later mess up physiological happenings. It matters little whether cuts are straight across or slightly angled. Protect from sun and wind with black or brown trash bags, covered baskets, moist burlap, and the like. Don't collect frozen broadleaf evergreen cuttings because of brittleness.

At the work table, remove lower leaves (by rough stripping or cutting) and flower buds, if any. If you wish, cut back large leaves, such as some rhododendrons, for easier handling and more efficient use of space. Basal wounding with a sharp knife or razor blade enhances rooting chances for some plants, notably rhododendron and some hollies (*Ilex* spp.). (See p. 35.) Treat cuttings with an appropriate rooting compound (see p. 50), stick in a moist medium of your choice (see p. 4), in a structure with overwintering protection—cold frame (including Nearing frame), hotbed or plastic tent in greenhouse or home. Plastic tents in the home need plenty of artificial light (see "Propagation Devices," p. 8). Temperatures, except for cold frames, should be 60–75°F, and bottom heat hastens rooting. Open benches in the greenhouse can be used with a misting set-up.

After rooting, pot or transplant into flats and give careful attention to watering. Plant into nursery beds after the last frost in spring. Cold frame cuttings will likely not be ready that soon and may not be ready for outdoor culture until the second spring.

Narrowleaf Evergreens

Make narrowleaf evergreen cuttings after a hard freeze or two. Often weather will necessitate collection from frozen plants. Be gentle because frozen foliage is brittle; thaw slowly and all will be well.

Collect cuttings of current season's growth, 3″–6″ or even 8″ long, with sharp shears or knife. Put in plastic bags immediately. The collecting cut is to be the only basal cut.

The position on the plant of a cutting is often important, especially with *Taxus* (yew) varieties. Upright shoots will produce plants that tend to grow vertically, bushy side shoot cuttings will grow into bushy plants with tendencies to horizontal growth.

Indoors, strip foliage from the bottom third of the cuttings. Wounding may aid in rooting. Difficult-to-root varieties may benefit from wounding and/or extra-strength rooting compounds. Reproductive buds are at the tips and reduction of leaf size is not practiced. Mist is not recommended for narrowleaf evergreens, but daily syringing is practiced in open (uncovered) benches in greenhouses.

Some evergreen plants that can be propagated from ripewood cuttings in late fall or winter.

Broadleaf Evergreens

Andromeda spp. (bog-rosemary)
Arctostaphylos uva-ursi (bearberry)
**Aucuba* spp.
*Azalea (*Rhododendron* spp.)

**Berberis* spp. (barberry)
Buxus spp. (box)
Calluna vulgaris (heather)
**Camellia* spp.
Cytisus spp. (broom)
Erica spp. (heath)
**Euonymus* spp. (wintercreeper)
Ilex spp. (holly)
Kalmia spp. (mountain laurel)
**Leucothoe* spp.
Paxistima spp. (pachistima)
Pieris spp. (pieris, andromeda)
**Poncirus trifoliata* (hardy orange)
**Pyracantha* spp. (firethorn)
Rhododendron spp. (evergreen rhododendrons and azaleas)
Teucrium chamaedrys (germander)
Vaccinium spp. (blueberry)

Narrowleaf Evergreens

Abies spp. (fir)
Cephalotaxus harringtonia (plum-yew)
Chamaecyparis spp. (false-cypress)
Cryptomeria japonica
Juniperus spp. (juniper)
Picea spp. (spruce)
Pinus spp. (pine)—late winter, or after girdling (see p. 42)
Sciadopitys verticillata (Japanese umbrella-pine)
Taxus spp. (yew)
Thuja spp. (arborvitae)
Tsuga spp. (hemlock) ❧

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*may be rooted from softwood cuttings also.

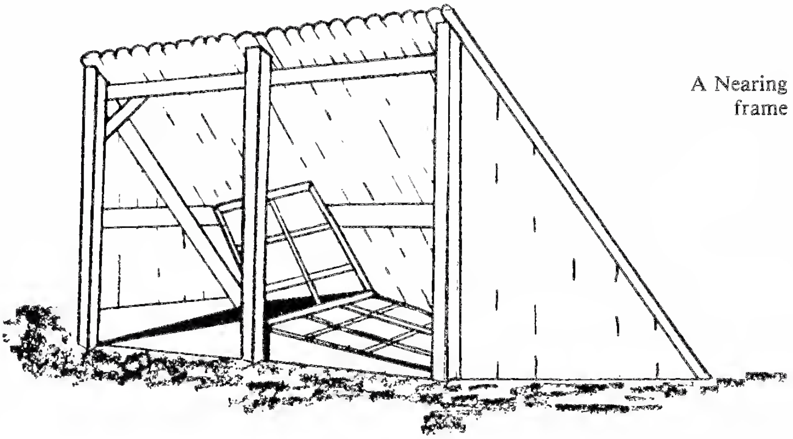
Nearing Frame

For rooting broadleaved evergreens with minimum attention, the Nearing frame (devised by Guy Nearing around 1950) has given excellent results. It's essentially a 3′ × 12′ box with two standard 3′ × 6′ glazed cold frame sashes. The box, about 18″ deep, is sunk below soil level in standard cold frame style, but the box is provided with a tight bottom of tongue-and-groove flooring. Four inches of peat moss on the bottom is topped with several inches of whatever rooting medium the propagator prefers.

A superstructure of 2″×4″ framing covered with galvanized steel or other durable opaque material is constructed above the box (see sketch), about 5 feet tall at the highest point. The unit must be sited with the open side facing directly north.

Cuttings are stuck and watered in and glass sash is put in place. Once a week or so, except in freezing weather, the cuttings are watered. Rooting is usually excellent by the following spring or early summer.

Plastic sash will reduce watering needs but increase chances of fungal diseases. ❧



A Nearing frame

M. Ecker

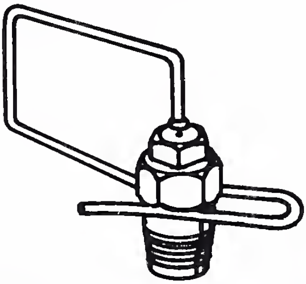
MIST PROPAGATION OF CUTTINGS

Cuttings under mist do not lose moisture readily, and high temperature is seldom a problem. Oddly enough, fungal diseases such as mildew are subdued by mist. No wonder mist has become the standard means of commercial propagation of softwood cuttings.

But there are some pitfalls and limitations. Power, water, or equipment failure on a hot sunny day can wipe out a crop. Mineral buildup from hard water on foliage reduces plant vigor and can interfere with electronic mist controls. Wind can play havoc with mist patterns. Also, mist is of questionable value for evergreen cuttings.

But pros outweigh cons. Mist can be used in the greenhouse or in outside beds, and a number of systems are adequate (see p. 46). When setting up a mist system, it's a good idea to test the nozzles for coverage with available water pressure, then plan nozzle spacing accordingly. Many propagators favor a design with supply pipe on or beneath cutting medium and nozzles on risers to eliminate dripping that overhead supply pipes allow. For outdoor beds, a two-line installation ensures good coverage in all but very high winds.

Intermittent mist uses less water than continuous mist and usually gives better rooting. A solenoid valve, electrically controlled, regulates water flow. A commonly used control for intermittent mist is a time clock that can be easily set for various combinations of mist duration and interval. Six seconds of mist per minute is recommended



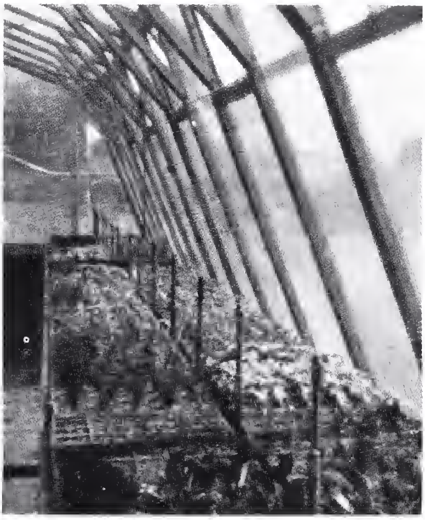
Mellinger's

Flora-mist fogger, a popular misting nozzle.

D.V. Sweet

Greenhouse bench with nozzles set on vertical risers from pipeline.

D. V. Sweet



Mist produced by the apparatus shown on p. 45.

by some operators; others prefer ten or fifteen seconds every three minutes.

A mist system medium must be very well drained and only 4″–5″ deep. Coarse sand and perlite are widely used.

As soon as rooted, cuttings should be hardened off by gradually reducing mist intervals, or by moving for a few days to a place where water loss will be minimal. Then rooted cuttings may be potted or planted in a nursery bed. ☘

A Mist Box

Doris Schuster

A mist box is an enclosure for rooting cuttings of perennials, shrubs, and other plants. It is a simple and inexpensive system to construct and operate, and it can give unending interest and an abundance of new plants.

My mist box is a four-sided enclosure, 36″ square, in a fairly sunny well-drained part of the backyard. It is a "continuous mist" system, operating through the heat of each day from about 7:00 AM to 5:00 PM, in summertime; yet it never uses more than ten gallons of water a day.

To begin, drive four stakes or poles 8″–10″ into the ground with poles extending 36″ aboveground, arranged in a square 36″ on each side. In the center of the square, rig an upright pipe or tube with a mist nozzle at the top about 18″ off the ground, and a horizontal supply pipe at ground level extending outside the square.

Around the four stakes, nail four 6″-wide side boards at ground level to make a box without a bottom. One side board should have a notch at the bottom to accommodate the water pipe.

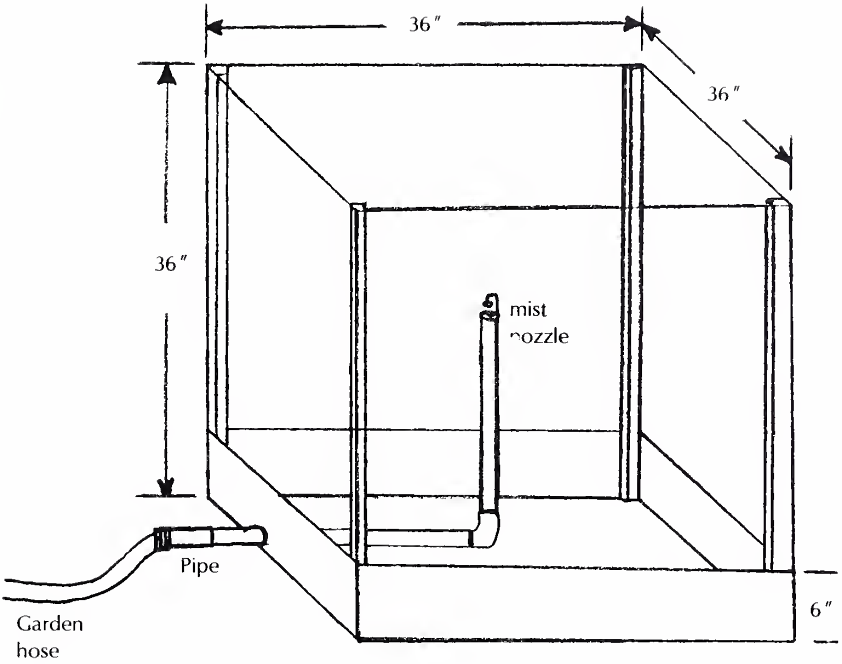
Wrap a piece of heavy (4 mil or thicker) clear plastic sheeting around the four corner posts to form the sides of the enclosure. The box has no top covering. With a staple gun, staple the plastic to each corner post and along the bottom boards. If you arrange for one side to open or be removable, it will be much more convenient when you are putting cuttings into the bed.

Fit the horizontal supply pipe with a garden hose connector and attach a hose to a water supply at one end and the mist supply at the other.

Now fill the mist box with 6″ of coarse builders' sand, packed firmly. Let the mist spray over it for several hours to settle the sand. It will take approximately 450 pounds of sand for a box this size.

To activate the mist nozzle, simply open the faucet slightly at the hose connection. A fine even mist that you can barely see will keep the leaves of cuttings moist while roots are forming. Turn on the mist as soon as the sun becomes warm and the dew on the leaves of your cuttings drys. Turn it off as soon as the heat of the day is over.

This, of course, is a primitive, attention-demanding system. More sophisticated systems employ strainers for cleanest possible water, and solenoid valves connected to



M. Ecker

A mist box fitted with mist nozzle and plastic sides, ready for sand and cuttings.

electric timers or moisture-sensing devices to deliver intermittent mist. (See mist suppliers on p. 76.)

Start using the mist box early in the year as you divide perennials. Insert small pieces of roots or crowns too small for transplanting directly into the garden. Dip first into rooting hormone, then tuck into the sand. I have succeeded with delphinium, phlox, coral-bells, coreopsis, hosta, iris, daylilies and many others. Chrysanthemum cuttings can be started in early May. After creeping phlox and basket-of-gold alyssum bloom, stick cuttings into the sand and almost every piece will root. When frost danger is past, slips of coleus, geraniums, impatiens, ivy, Joseph's coat and other house plants will root with ease under the mist.

About mid-June, after shrubs and roses have flowered, is an ideal time to take cuttings from them. Boxwood, euonymus, flowering quince, mock-orange, deutzia, some viburnums, and red-twig dogwood are a few of the shrubs I have rooted easily. Choose new-season growth that has begun to harden but is not yet completely brown and woody. Take lengths 8″-12″-long, strip leaves from the lower two inches; score the bark there and dip end into hormone powder. Then insert them firmly in the sand. Some kinds will show no growth before the growing season ends but if the stems are still firm, leave alone and they will probably start growth the next spring.

When transplanting rooted cuttings out of the mist bed to the open garden, it is important, first, to prepare the soil well with additions of peat, compost and sand worked in; and second, to shade the new transplants for a few days until they recover. I set boxes over them by day, and remove them each evening. I also water plants at transplanting with a weak fertilizer solution.

If for some reason the mist runs all night, it will do no harm. In fact, sometimes when I must be away for several days, I let the nozzle run continuously at low output.

To winterize the box in October I merely disconnect the garden hose and roll it up for storage. The mist nozzle is taken off and stored carefully with other garden equipment indoors so it will not be damaged. It is not necessary to cover the mist box but mulch can be applied. ⁂

When ordinary cuttings fail,
try greenhouse-forced cuttings...

Cuttings by Force

Many species that don't respond to softwood-cutting propagation efforts can be successfully propagated from cuttings of ultra-soft shoots forced under greenhouse or similar conditions (such as a lighted indoor propagating chamber).

Some plants in this category are mountain-laurel (*Kalmia* spp.), pieris (often called andromeda) (*Pieris* spp.), deciduous azaleas (*Rhododendron* spp.), *Fothergilla* spp., *Stewartia* spp. and others.

A greenhouse or superior-quality lighted indoor propagating unit may be the path to successful propagation using the forced-growth-cutting method.

For years, limited numbers of plants from difficult stock have been produced by cuttings from plants brought into greenhouse growing conditions in mid-winter after having gone dormant in autumn. In this unseasonable environment ultra-soft shoots result, are cut off, stuck in plastic tents or mist beds, and rooted in high percentages.

At first propagators set the stock plants, balled and burlapped or potted, conventionally upright on a greenhouse bench. Somewhere in the past a thinking person obtained much more new growth and thus many more cuttings by placing stock plants horizontally, redistributing the flow of hormones that ordinarily goes from top to roots and promoting new growth all along the axis of the stock plant instead of only from terminal buds.

Root-promoting chemicals may or may not help forced cuttings to root, but high humidity and temperatures near 70 °F do.

The stock plant(s) may be salvaged after taking cuttings. Return to upright position, allow new shoots to develop undisturbed, and gradually harden off the plant(s) by extra ventilation and replant outside after frost danger. ❧

Good propagators need good...

Propagating Tools

The grafting knife, with which propagators not only graft but collect and prepare cuttings, including wounding, is a must for a serious propagator. (Pruning shears are better for hardwood cuttings.) The knife is simple in design with a straight cutting edge which is beveled on one side only. When held in the right hand with the edge away from the knuckles, the bottom side is flat, the upper side is bevelled at the edge. Left hand knives are available.

Budding knives have a curved cutting edge with a blunt protuberance on either blade or handle for gently prying open the T-cut on the understock.

Knives are fixed–blade or folding; combination folding knives have both grafting and budding blades. A leather sheath should be purchased for a fixed–blade knife. Very good knives (Tina and Kunde are excellent brands) cost roughly half as much as a decent pair of shoes.

An Arkansas honing stone, lubricated with oil or water, is a good choice for keeping the necessary razor edge on a grafting knife.

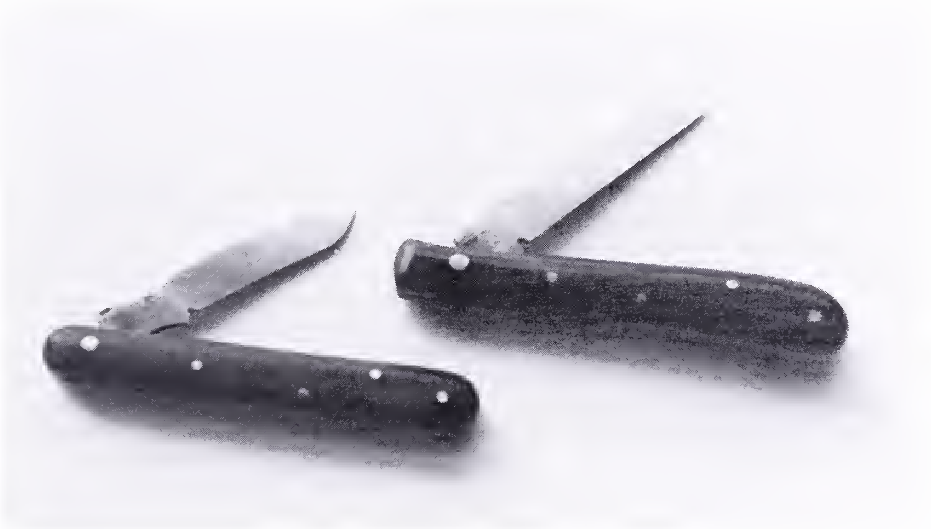
Pruning shears are of two types, draw cut (scissors action) and snap cut (a cutting blade impinging on a flat surface). The former makes a cleaner cut; snap cut shears bruise plant tissue while cutting. Though it makes little difference in taking cuttings, most shears are designed for right hand use but left hand models are available. Top quality pruning shears usually cost thirty to forty percent more than knives of comparable quality.

Seed sowing may or may not be ameliorated by a battery operated vibrating device.

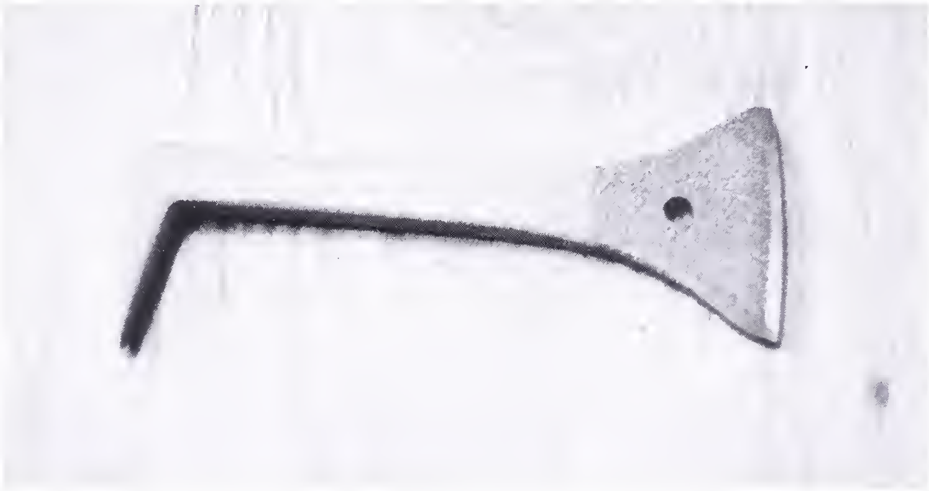
Plastic labels and a waterproof pen are paramount for keeping look-alike cultivars separated.

Possibly the most important tool is a notebook for recording the details of your propagation adventures. You only think you'll remember. ☙

Photos by C.T. Cleaves



At left is a grafting knife with a straight edge. Right, a budding knife with curved edge and "ear" for teasing bark away from wood.



A cleft grafting tool. The broad end is used to split the stock (by tapping with a mallet, if necessary). The narrow end holds the split open while scions are inserted.

Whatever they're called,
they help cuttings make roots...

Hormones, Auxins, Growth Regulators, Root Promoters, Rooting Compounds

Strictly speaking, hormones are substances produced by plants that regulate physiological processes within the plants. Auxins produce cell elongation and affect other plant processes. Regulators affect growth in various ways.

Who cares? As long as we dip the end of a cutting in some powder and get roots easier, faster or better, we can call it whatever we want. (Rooting powders as we know them now won't put roots on all plants—some species and cultivars still must be seeded, layered or grafted.) Commercial operators often use liquid formulations of root promoting chemicals, but for backyard propagators powders are better.

The chemical which probably has been most widely used for treating cuttings is 3-indolebutyric acid (referred to as IBA). It is a safe and effective root-promoting substance for a wide range of plants. Alpha-naphthaleneacetic acid (NAA) and the closely related naphthaleneacetamide (NAd) also are used extensively. Captan and Benlate are common fungicides that can be combined with the above chemicals to further promote rooting.

Commercially available products include: Rootone F, a combination of four root promoters totaling .17%, plus a fungicide, is a rather mild powder formulation for easy-to-root plants; Hormodin, an IBA powder, is available in three strengths, No. 1 (.1%), No. 2 (.3%) and No. 3 (.8%); Hormex rooting powders contain IBA in six strengths from .1% to a very powerful 4.5% (which will burn the bottoms right off most cuttings, so choose judiciously). See "Hormones on the Horizon" below for more news about hormones, or whatever they are. ✤

Hormones on the Horizon

Better rooting hormones are appearing. One is the result of thirty years work by Oregon nurseryman Edsal Wood. Wood's Rooting Compound, a liquid hormone which "can replace a whole range of powdered formulations," has been registered by the Environmental Protection Agency after seven years study. Tests show that the Wood hormone does not generally increase the percentage of cuttings that root, but it does produce heavier root systems. It is now being marketed, with a slight change in formulation, as Dip 'n Grow, by the CR Chemical Research Corporation (11040 S.E. Mill Court, Portland, OR 97216).

Just patented is a new synthetic auxin developed by Dr. Jack Gaines of the South Dakota School of Mines and Technology (Rapid City, SD 57701). After testing, Dr. Bruce Haissig, Chief Plant Physiologist at the USDA Forest Sciences Laboratory (Rhinelander, WI 54501), described it as "the best root-promoting agent available." It may come on the market soon.

Work is still on-going on the powerful rooting compound discovered by Prof. Makota Kawase of the Ohio Agricultural Research and Development Center (Wooster, OH 44691). This extract from the willow is not a hormone but may be the long-sought rhizocaline, a substance which greatly enhances the action of hormones. If you'd like to experiment, steep willow cuttings in water for 48 hours, then place softwood cuttings of any woody species in the same water for up to 24 hours. Then immediately treat them with Hormodin #2 and stick them in the cutting bed. Also try soaking seeds of woody plants in willow water, and watering transplants with it—it may stimulate germination and root development, too. ✤

Reprinted from *The Avant Gardener*

Try root cuttings when shoots are hard to root . . .

PUTTING SHOOTS ONTO ROOTS

Propagation by root cuttings may have originated after young plants were observed developing from roots left after certain plants were dug.

Root pieces of many woody and herbaceous plants may be taken at various times of year then placed in a moist, well-drained medium at relatively cool temperatures (50–60 °F).

Dormant plants may be dug, root pieces pirated, and the plant reset. Or careful excavation can yield suitable roots with little harm to the parent plant. Be certain the roots so collected are of the desired plant and not from some other plant nearby; also, roots from grafted plants will propagate the understock, not the desired cultivar.

Ideally, root cuttings should be 1″-to-4″ long and ¼″-to-½″ in diameter. Exceptions are plenty—*Anchusa* (bugloss) root pieces only ¼″ long root readily. Some fibrous lateral roots on cuttings are desirable. Cuttings can be laid horizontally on top of 3″ of medium in a pot or flat and covered with ½″-to-1″ of the medium, but many propagators prefer placing the pieces vertically, claiming better shaped plants as a result.

A medium appropriate for stem cuttings will suffice for root cuttings. It should be well drained but not allowed to dry out. Some growers put root cuttings out-of-doors in sandy earth.

Root cuttings taken in autumn may be put into cold frames or greenhouses. Spring cuttings can be put in frames or just set out of doors in a partly shady spot.

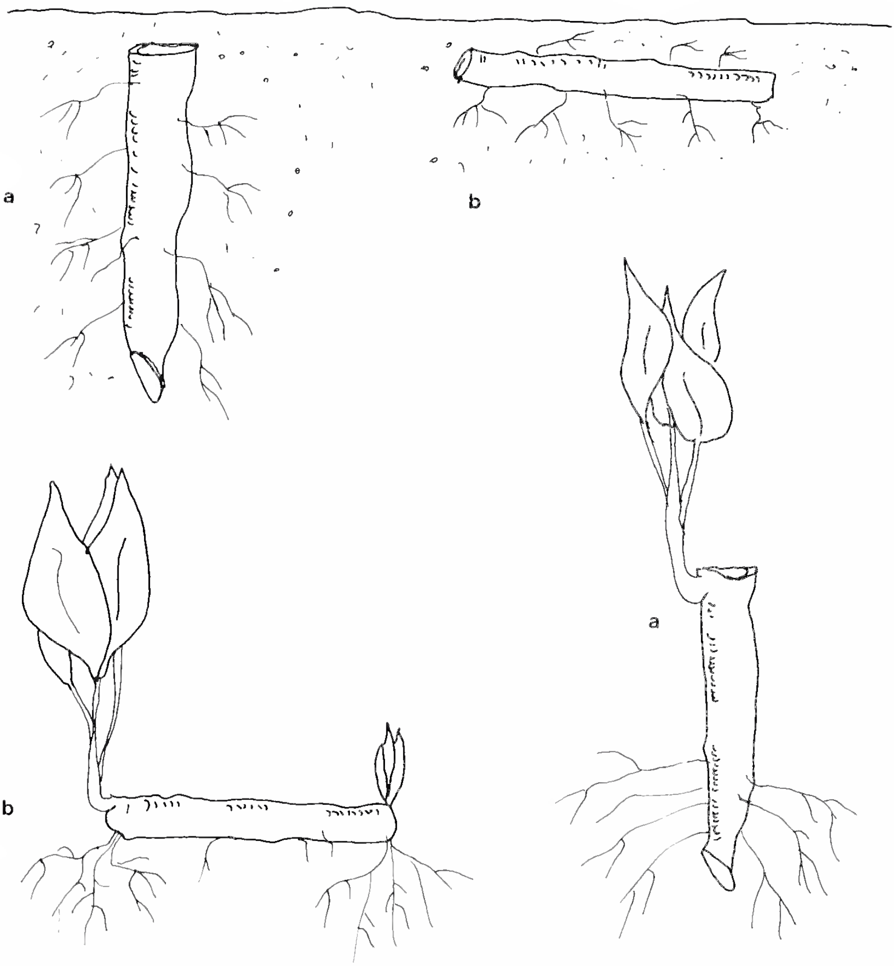
Root cuttings from some variegated-foliage plants don't come true, producing normal green-leaved plants.

Some herbaceous plants that can be propagated by root cuttings:

Acanthus
Anchusa (bugloss)
Arabis (rockcress)
Ascelpias tuberosa (butterfly weed)
Convolvulus (bindweed)
Dicentra (bleeding-heart)
Echinops (globe thistle)
Geranium (true geranium)
Gypsophila (baby's-breath)
Ipomoea (morning glory)
Oenothera (evening primrose)
Papaver orientale (Oriental poppy)
Pelargonium (geranium)
Phlox
Plumbago (leadwort)
Primula (primrose)
Saxifraga (saxifrage)
Trollius europaeus (globeflower)
Verbascum (mullein)
Yucca (Adam's needle)

Some woody plants that can be propagated by root cuttings:

Acacia
Aesculus (buckeye, horsechestnut)
Albizzia (silktree)
Alnus (alder)
Amelanchier (serviceberry)
Amorpha (leadplant, false indigo)
Aralia—some species
Asimina (paw-paw)
Azalea (*Rhododendron* spp.) (deciduous azaleas)
Calycanthus (strawberry-bush, sweet-shrub, Carolina allspice)
Campsis radicans (trumpet vine)
Caragana (pea shrub)
Celastrus (bittersweet)
Cercis (redbud)
Cladrastis (yellow-wood)
Clematis
Clerodendron (glorybower)
Crataegus (hawthorn)
Daphne
Eleagnus angustifolia (Russian olive)



K. Kling

Top left, sturdy root pieces are easily placed upright. Top is cut square and bottom slanted for quick differentiation when sticking cuttings. Top right, thin and/or flexible roots are more easily laid horizontally and covered with ¼″–½″ of medium. Bottom shows sprouting and new roots on cuttings.

Elliottia
Ficus corsica (fig)
Fothergilla
Gymnocladus (Kentucky coffeetree)
Hypericum (St. Johnswort)
Lagerstroemia (crape-myrtle)
Ligustrum (privet)
Lonicera (honeysuckle)
Maclura (Osage-orange)
Malus (apple, crabapple)
Phellodendron (Amur cork tree)
Prunus (cherry, plum)
Pyrus (pear)
Ribes (currant)
Rhus (sumac)
Robinia (locust)
Rosa (rose)
Rubus (blackberry, raspberry)
Sassafras
Sorbus (mountain-ash)
Stewartia
Tilia (linden)
Ulmus (elm)
Viburnum
Weigela
Xanthoceras (yellowhorn)
Xanthorhiza (yellowroot)
Zanthoxylum (prickly ash) ❧

An almost foolproof method of vegetative propagation . . .

SIMPLE LAYERING

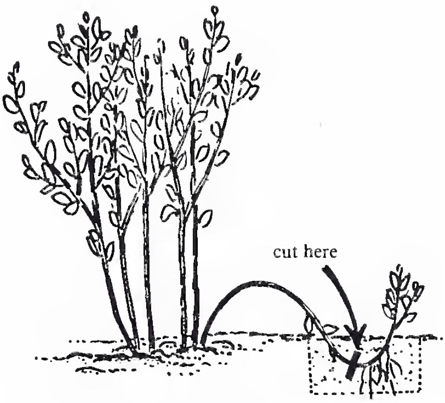
John P. Mahlstede

Layering is the technique of rooting shoots while they are still attached to the parent plant. It differs from propagation by cuttings in that the "cutting" is not detached from the parent until after it has rooted.

Layering is used to propagate plants that do not come true from seed, that cannot be grafted or budded easily, that fail to sucker or are difficult to root as cuttings. In its various forms it is a rather cumbersome method of increasing plants and therefore not so desirable when quantity is wanted. For the gardener who wants to increase only a few plants, it is a very good method.

Simple layering is accomplished by bending a branch of a plant to the ground and covering a portion of it 5″-to-10″ from the tip with a light soil mixture. It is advisable that the soil around the parent plant be prepared before layering by working in sand, peat moss, or some other material to lighten and condition the soil. The medium in which the layer is to be rooted must be well drained and aerated, yet have a good capacity for holding moisture.

Before covering the branch with soil, girdle it by removing a ring of bark about 1″ wide from the portion that is to be covered, Or wound by making a diagonal knife cut up and about half through the stem on the lower surface. To hold the cut open on a less flexible stem, insert a wooden matchstick sideways. If the branch or cane is particularly delicate it may be advisable to make the wound or knife cut on the upper surface of the stem, twisting it as the layer is placed in the soil. Wounding in these ways exposes tissue with root-forming potential and tends to hasten the process. To additionally speed formation treat the wound with a root-inducing hormone powder. Hold the layer in place in the soil with a peg made of a U-shaped piece of heavy wire or with a forked branch as shown in the illustrations. A heavy stone also can be used.



Simple layering

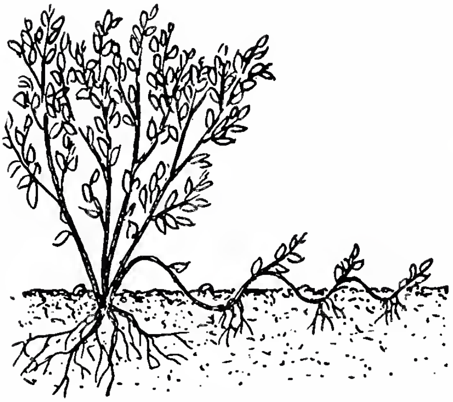
Redrawn from author

Simple layering may be done in early spring, using still-dormant wood produced during the previous growing season, or in late summer, using current season's growth which has not yet become woody or hardened. Many species and cultivars can be propagated by this method; those which produce numerous low, flexible branches are particularly adapted to it.

The rapidity with which layered shoots root varies with the kind of plant, age of the shoot, and conditions during the rooting period. Easily rooted plants will be established by early autumn, and can then be separated from the parent plant, transplanted with a ball of soil, cut back, shaded and watered. Where winters are severe it is advisable to leave the rooted layer attached to the parent until early spring, when it can be separated and transplanted either bare-rooted or with a soil ball. For some slow-rooting plants such as magnolia and most evergreens, you may have to leave the layer attached to the parent for as long as two or three growing seasons before a root system large enough to support the new plant is produced.

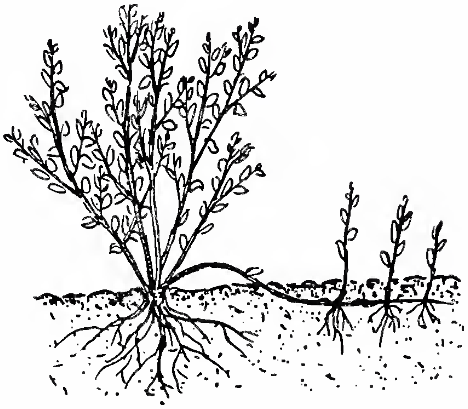
[*Ed. note:* Another form of simple layering is called tip layering. Used commercially to some extent with bramble fruits (black raspberries, blackberries, dewberries), it is done by making a slanting cut in the earth with a spade, inserting a stem tip and firming it into the earth with one's foot. The tip roots and new plants are generated.]

Other Methods of Layering in the Ground



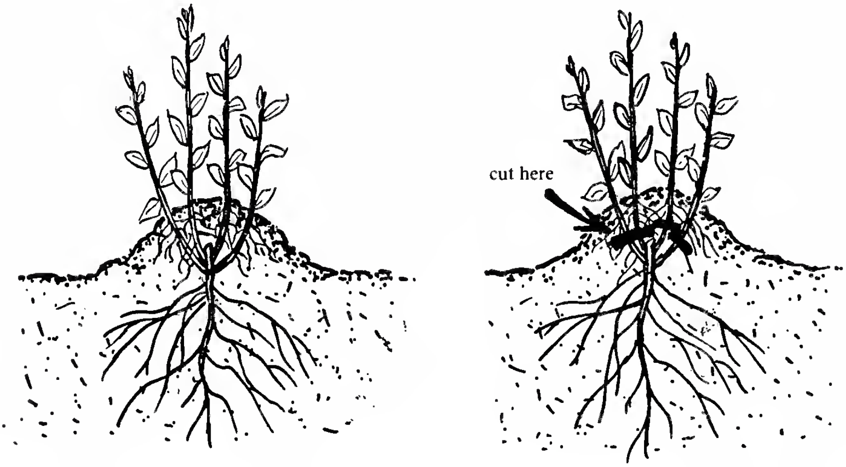
Serpentine or Compound Layering

For viny plants such as grapes, wisteria, clematis and ivy. It's just a series of simple layers (girdling or notching, hormone powder, prepared soil, peg or stone, keep moist, see p. 53) on the same stem.



Continuous or Trench Layering

Employed to propagate fruit trees (apple, plum, cherry). A branch is pegged down in an open furrow or trench 4″–6″ deep. As shoots grow vertically from buds along the prostrate stem, soil is gradually pulled into the trench around shoots until level with the original surface. After roots form, by the following spring or maybe the second season, cut apart and transplant.



Mound or Stool Layering

Used for plants that freely form shoots near ground level. A healthy plant is cut back close to ground level in early spring. As shoots arise, soil is mounded around them at intervals until the mound is 6″ high. Soil must be kept moist throughout the season. Rooted shoots are removed the following spring and the process may be repeated. Mound layering has been applied to magnolias, hydrangeas, gooseberries, azaleas and many others. ❧

GRAFTING AND BUDDING WOODY PLANTS

Adapted from articles by

Roy M. Nordine

Grafting (including budding) is a way to propagate quantities of woody plants whose seeds are nonexistent or do not "come true" and whose cuttings are difficult to root, and which are too unwieldy for layering.

In addition, grafting, by use of appropriate understocks and techniques, can produce dwarfed trees, put weeping or globe varieties at appropriate heights on "standards," and add new varieties to mature fruit trees.

Recent advances in propagation by cuttings have made grafting more-or-less obsolete for rhododendrons, magnolias, and others, but grafting and budding are still widely used for increasing flowering and shade tree cultivars, many roses, most fruit trees, tree peonies, certain junipers (especially upright cultivars of *Juniperus chinensis* and *J. virginiana*), pine, Colorado spruce and other conifers.

The Grafting Process

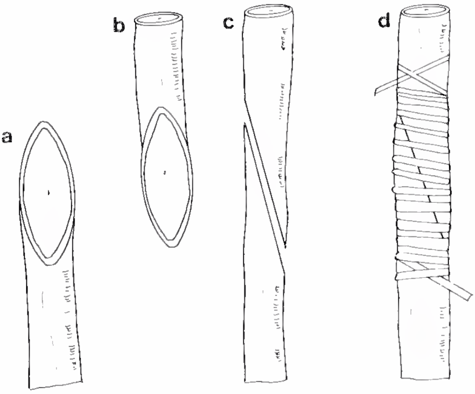
Grafting is accomplished by uniting a piece of stem with several buds (in budding, a single bud) of the desired variety to another plant or plant part that furnishes a root system for the new plant.

The stem piece of the desired variety is the scion (pronounced "sigh'-un"); the piece it is attached to is the understock. The understock may be a seedling, rooted cutting, a piece of root, or a mature tree (see "topworking" p. 59).

Scions are generally of one-year-old shoots from 1/8″–1/4″ in diameter and 4″–6″ long that also has several buds. Understocks are usually one- or two-years-old of the same diameter as the scion or slightly larger. Sizes and ages may vary considerably with various species. They may be growing in soil out-of-doors, or in small pots, or may even be bare-rooted.

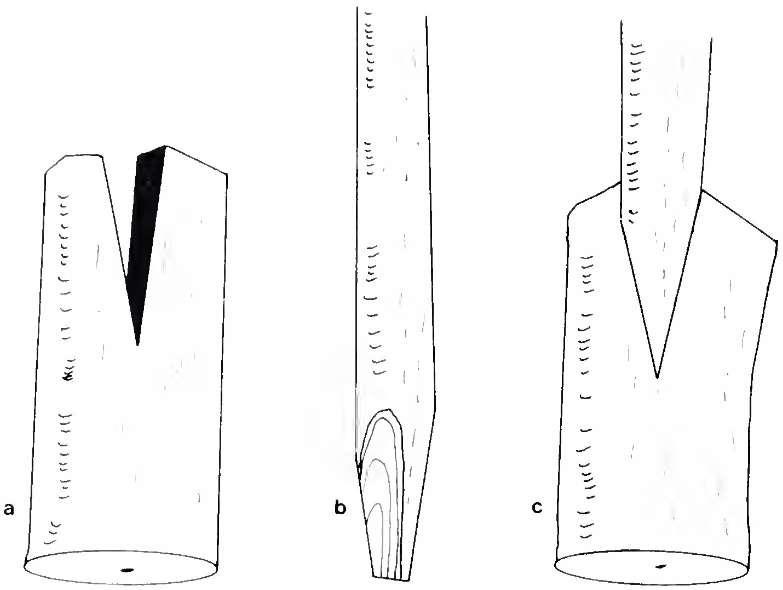
It's essential that scion and understock be closely related botanically. Pines are grafted on pines, apples on apples, and so on. A few plants have wider ranges of compatibility, especially the Olive Family (lilac can be put onto privet or ash) and Rose Family (cotoneaster can be grafted to mountain-ash or hawthorn); some are extremely exacting (white oak cannot be attached to red oak).

No matter how compatible, scion and understock cannot unite if the cambium layers (the thin green or sometimes reddish or white layer of tissue between bark and wood) don't come in contact. To ensure



The splice graft, a fast method for grafting deciduous plants, usually on potted understocks. (The beginner may have difficulty keeping cambium layers aligned while binding.) a) Understock sliced smoothly with a slanting cut three or four times as long as the diameter of the stock; b) scion cut similarly; c) cambium layers aligned; d) graft bound with string, rubber bands or grafting tape. Binding must be carefully removed after "knitting."

Drawings by K. Kling unless noted



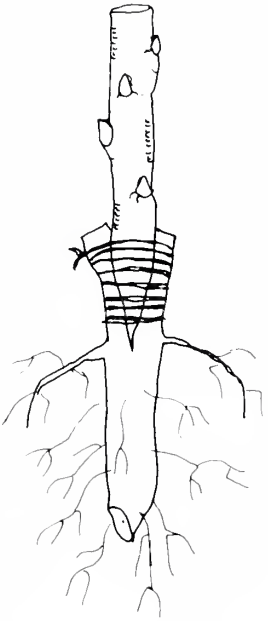
Above, the wedge, or cleft, graft, a method used for deciduous plants with potted understock and sometimes with understock growing in outdoor nursery beds. a) The understock is split; b) scion is cut at base into a chisel shape; c) scion is placed into stock so that cambium layers align or cross on at least one side. Binding may or may not be necessary. Grafting wax or other compound must be applied, or entire graft covered with clear plastic. Below, the piece-root graft where a scion is grafted onto a piece of root from a compatible species; in this case the wedge graft is used. The union may be planted with a bud or two protruding in potting medium and placed in a greenhouse, frame, or small plastic unit.

contact, at least one side of the scion's cut surface (when smaller than understock) is lined up with one side of the understock. Since union of only one cell of scion with one of understock is necessary to initiate a successful graft, some propagators angle the scion slightly so cambium layers cross.

And no matter how compatible or how good the contact, cambium tissues won't unite if either is dried out, so use scions immediately or store in moist sphagnum moss in plastic bags in a refrigerator until needed.

The next requirement of successful grafting is tight binding. Rubber band ties are preferred by many; moderate stretching while winding ensures firmness and the rubber may disintegrate before it becomes too tight as the graft grows in diameter. Grafting tape can also be applied firmly with relative ease. Both are available from nursery supply companies.

After the graft is fully healed (from one



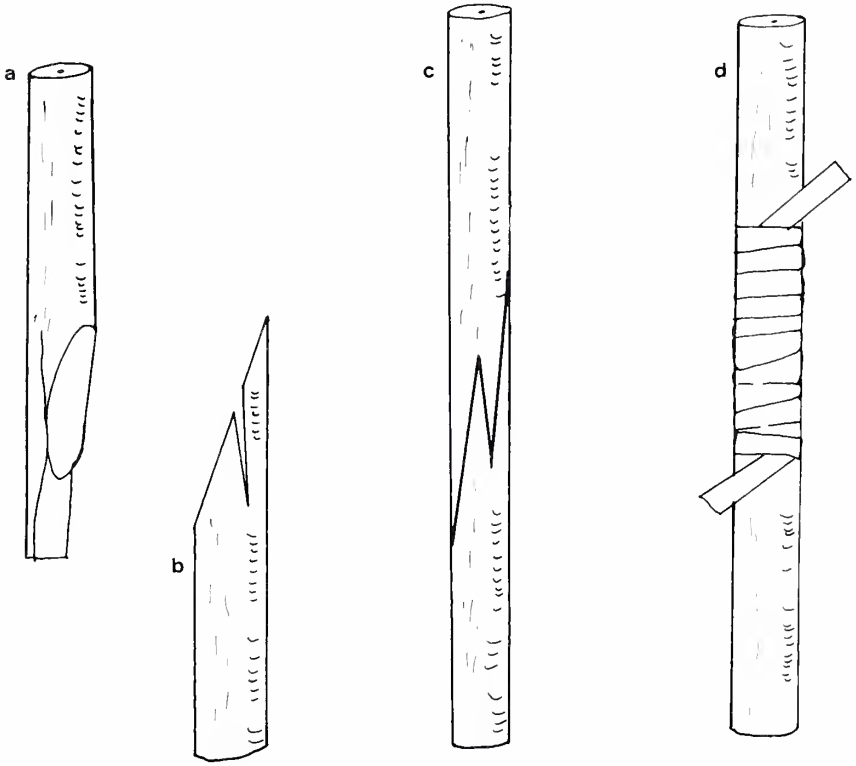
to several months), ties must be carefully cut away before they constrict growth and girdle the new plant.

Sources of Understock

Commercial propagators have ready access to a variety of understock seedlings, but the amateur is more limited. Some retail mail-order nurseries sell seedlings of dogwoods and other deciduous trees; several sources offer conifer seedlings, and only recently dwarfing root stocks for apples have come to the retail marketplace (see p. 76).

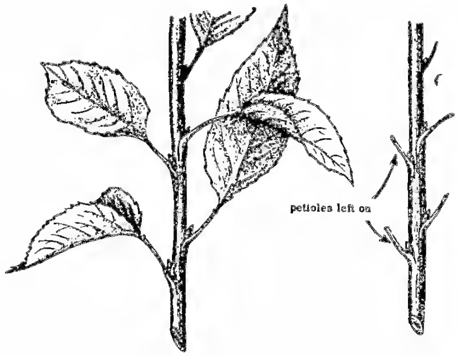
If seedlings are not available, one may be able to grow the appropriate understocks from purchased or collected seeds (see p. 76). Cuttings of easily rooted types of chamaecyparis (false-cypress), juniper, yew and arborvitae can be used as understock for the hard-to-root cultivars of the same genus. For example, the well-known Hetz juniper (*Juniperus chinensis* 'Hetzii') roots easily and then can serve as understock for cultivars of *Juniperus chinensis, J. virginiana, J. scopulorum, J. rigida,* and others that resist rooting.

In the case of deciduous trees and shrubs (e.g., a favorite apple or lilac), pieces of root carefully dug and removed from the same or similar plant will accept a properly grafted scion.

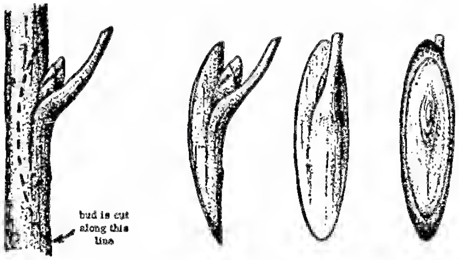


The whip, or tongue, graft, a popular method for grafting deciduous plants. More cambium is exposed, increasing chances of success; scion fits snugly to understock, facilitating binding. a–b) After cuts to scion and understock (as in the splice graft) longitudinal splits are made in both pieces, about ⅓ of the way down from the pointed edge; c) scion fitted to understock with cambium layers aligned or slightly crossed on at least one side; d) snugly bound with string, rubber band or grafting tape. Treatment is the same as for d) in the splice graft.

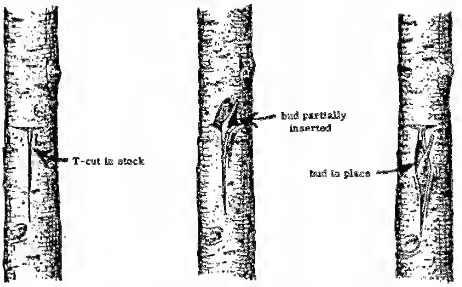
Drawings by Peter K. Nelson



Suitable branch for providing buds is called a bud stick. At right blades of leaves have been removed; petioles are left to provide for holding buds.


bud is cut along this line

Shield bud enlarged, showing where it is cut from bud stick. Right, side, front, and rear views of bud.



Left, stock with T-cut for inserting shield bud. Center, bud partially inserted after bark of stock is loosened. Right, bud in place and ready for wrapping with rubber band, twine or tape.

Timing and Techniques

Splice grafting is a common method of grafting deciduous plants. Remove the top portion of a potted or bare-root understock with a slanting cut about four times as long as the diameter, cut the base of the scion similarly, align for cambial contact, bind firmly, and wrap the grafted portion in plastic or seal it with a commercial grafting wax or compound. This method and a number of variations can be performed in a cool greenhouse (55 °F) in winter, a cold frame in late winter, or out-of-doors just before growth begins in spring.

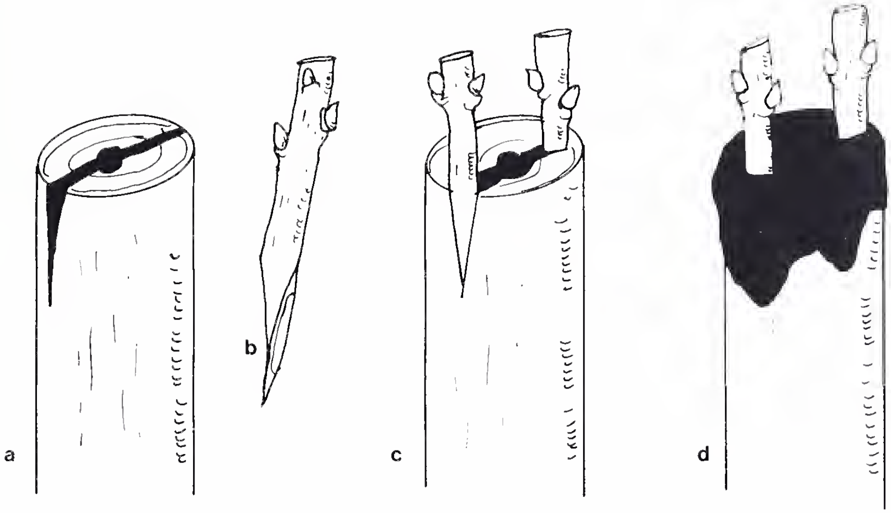
Cleft or saddle grafting on understocks growing out-of-doors in soil is sometimes employed just before spring growth. The union may be waxed or plastic wrapped, or the entire system may be enclosed in an inverted jar or plastic bag, then shaded with cloth to reduce heat buildup from the sun's rays.

Budding is a form of grafting commonly used for roses, fruit trees, and some shade tree cultivars. It can be done only when bark separates or peels easily from the wood, usually in late July or August. Understocks usually are seedlings in their second growing season; they can be older. Scion material is from current year's growth. Select stems of more-or-less pencil diameter. Soon after cutting the stem segments (called bud sticks), remove the leaves, allowing only a short piece of the petiole (leaf stalk) to remain. This will serve as a handle in the budding operation. Place the stem segments in water or, better yet, wrap them in polyethylene film and store in a cool place until used. If refrigerated at 40 °F, scion wood can be kept for several days.

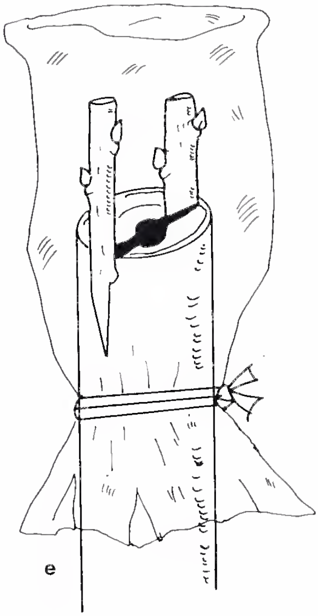
A simple method of budding is shown in the illustration. The bud is cut from the bud stick in the shape of a small shield. The small bit of wood inside the shield is sometimes removed, leaving only bark and cambium.

A T-cut is made in the stock and the bark loosened gently. The bud shield is inserted under the bark and slipped down until it fits snugly, and wrapped, usually with a special rubber strip. On a small scale, cut rubber bands will do. Remove band after two weeks.

Early the following spring the stock is cut off. When the budded plants are to grow as



Top working with the cleft graft, used frequently with fruit trees. a) A truncated branch of approximately an inch in diameter is split; b) a scion, about ½″ in diameter and 3″ long, with two or three buds, is cut on opposite basal sides to form a wedge shape; c) two scions are fitted into the split with outer cambium layers in contact as much as possible. Binding is not necessary, the tension in the split stock will hold scions firmly; d) all exposed tissue is covered with grafting wax to conserve moisture; e) instead of sealant, or in addition to, a plastic bag can be secured over the graft. As soon as growth begins on one or more scions, plastic must be loosened and soon removed. If both scions "take" the weaker should be removed at the beginning of the next growing season.

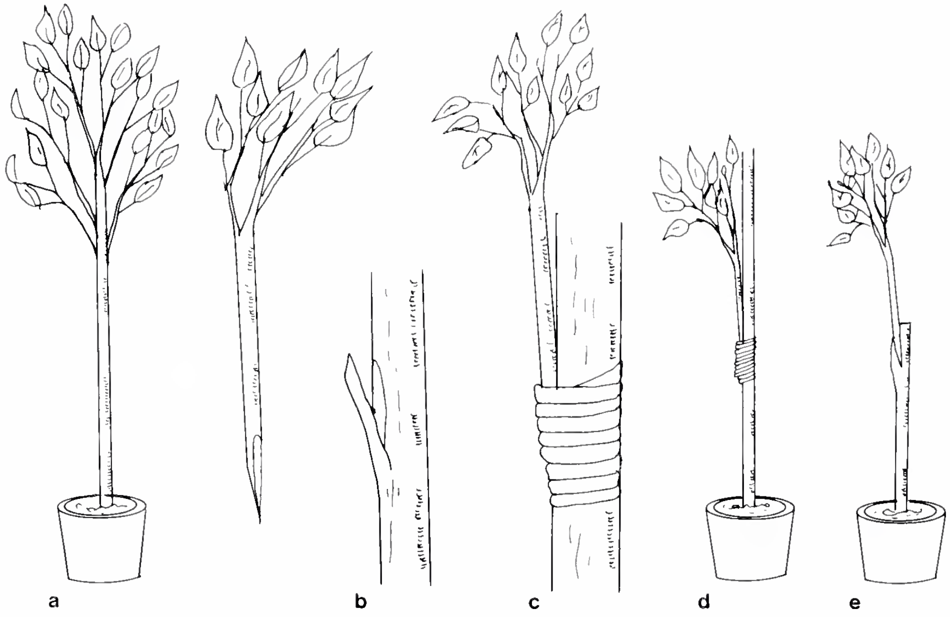


shrubs, the understock is cut just above the T; when trees are to be grown, the understock is cut about 6″ above the bud. This remaining stock can serve as a stake to which the growing bud is tied; then it will grow straight and not be broken the first season by wind or rain. The stub is cut just above the union in late summer. Suckers that may be produced by the understock should be removed.

Top Working

Top working is performed in early spring to introduce new cultivars to a more-or-less mature tree. For example, standard apple cultivars may be grafted to branches of a chance seedling apple tree which produces unpalatable fruit.

Early spring is the time to truncate key branches and insert scions, then cover the union with grafting wax or grafting compound. A plastic bag over the scions and union is employed by some, but it must not be left on after growth starts.



Side grafts, usually used for needle evergreens on potted understock. a) Potted understock; b) scion cut on opposite sides into a narrow wedge with tip blunted; c) scion with flap of bark cut and left intact at bottom, within an inch or two of crown; d) scion fitted to stock and securely bound with string, rubber band or tape. Graft area must be submerged in moist medium, treated with sealant compound, or wrapped with plastic; e) after "knitting" begins, half of the foliage of the stock plant is removed; f) when knitting is complete, balance of understock is cut away just above the graft.

Grafting Evergreens

The usual procedure for grafting evergreens is to pot two- or three-year-old seedlings or one- or two-year-old cuttings of appropriate understock in the autumn. A month or so before grafting these are brought into a greenhouse to start root growth.

Scions, newly-collected or from cold storage in plastic bags, are joined to the understock using a side graft or similar technique. The time-honored method of plunging pots in moist peat moss to cover the union may be replaced on a small scale by waxing and wrapping with plastic.

Understock tops are cut away by half at the end of a month and removed completely after two months, leaving the scion joined to the understock. A hotbed or well-lighted indoor propagating case could substitute for the greenhouse.

Evergreen grafting is inherently more difficult than that of deciduous plants. The serious amateur should consult specialized textbooks and local practitioners for detailed information. ⁂

Understocks for Budding and Grafting

In general, a cultivar of a given species is best grafted onto an understock (rootstock of the same species). But there are a few extra-species exceptions, and some intra-species rootstocks for dwarfing purposes.

Fruit Tree Understocks

Type	Understock
Apple, *Malus* cultivars	Alnarp No. 2—vigorous Merton-Malling 111—semi-vigorous Merton-Malling 106—semi-dwarfing Malling 7—semi-dwarfing Malling 26—dwarfing Malling 9—very dwarfing
Cherry, *Prunus* cvs.	*Prunus mahaleb*—normal
Peach, *Prunus* cvs.	*P. domestica,* (common plum)—normal; *P. besseyi,* (sand cherry)—dwarfing
Prune and plum, *Prunus* cvs.	*P. cerasifera,* (myrobalan plum)—normal
Pear, *Pyrus* cvs.	Seedlings of pear cvs., such as 'Bartlett'—normal East Malling Quince A—dwarfing

Deciduous Trees

Type	Understock
Birch, *Betula* cvs.	*Betula pendula* (European white birch)
Cotoneaster spp. and cvs.	*Crataegus* spp. (hawthorn) *Cydonia* spp. (quince) *Sorbus* spp. (mountain-ash)
Wintercreeper and spindletree *Euonymus* spp. and cvs.	*Euonymus europaea* (European spindletree) *E. atropurpureum* (wahoo)
Ash, *Fraxinus* spp. and cvs.	*F. excelsior* (European ash)
Magnolia spp. and cvs.	*M. acuminata* (cucumber-tree) *M. tripetala* (umbrella magnolia)
Oak, *Quercus* spp. and cvs.	red oak group spp. and cvs. on red oak spp.; white oak group spp. and cvs. on white oak spp.
Rose, *Rosa* spp. and cvs.	*R. odorata* (tea-rose) *R. multiflora*
Lilac, *Syringa* spp. and cvs.	*S. vulgaris* (common lilac) *Ligustrum vulgare* (common privet)

Evergreens

Type	Understock
Fir, *Abies* spp. and cvs.	*A. concolor* (white fir)
Juniper, *Juniperus* spp. and cvs.	*J. chinensis* (Chinese juniper) *J. chinensis* 'Hetzii' (Hetz juniper) *J. virginiana* (red cedar)
Spruce, *Picea* spp. and cvs.	*P. abies* (Norway spruce)
Pine, *Pinus* spp. and cvs.	Two-needle pines for any two-needled species; three for three-needle and five for five-needle pines. Or almost any pine on *P. contorta,* (shore pine).

Even if it doesn't *work, it'll impress your friends...*

Nurse-Seed Grafting

Old-timers, at least as far back as the turn of the century, would split the base of a cutting and insert a wheat seed. Growth promoting substances, produced as the wheat seed imbibed water and germinated, seemed to aid rooting of the cutting.

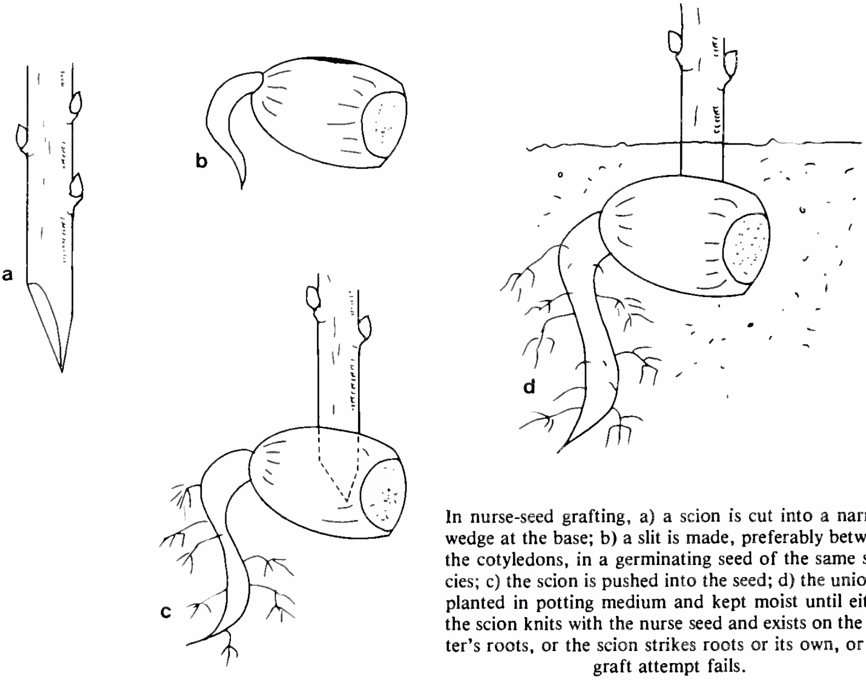
By the 1940s, chemical rooting aids (rooting "hormones") made the practice obsolete. But even so, many plants resisted rooting and in the 1960s some enterprising propagators began "nurse-seed" grafting of hard-to-root cultivars of species with large seeds of hypogeous germination (seeds stay in place when germinating, contrasting with epigeous seeds that emerge from the soil).

The technique consists of inducing seeds of the same species to germinate, cutting away the epicotyl (immature shoot) making a slit with a sharp knife between the cotyledons inside the seed, cutting the basal end of a dormant scion into a narrow wedge, and pushing the scion into seed.

The strange graft is treated as a cutting with the seed placed an inch below the surface of the medium in a cold frame, plastic tent, or under mist. After strong scion growth, the new plant is potted and handled from then on in the same way as seedlings and rooted cuttings.

Castanea (chestnut) cultivars respond well when dormant scions of one-year-old growth are used. *Camellia* scions may be dormant or active.

Experiments with *Aesculus* (buckeye and horse-chestnut), *Quercus* (oak), *Juglans* (walnut), *Carya* (pecan) and *Persea* (avocado) using dormant scions have also resulted in degrees of success.



K. Kling

In nurse-seed grafting, a) a scion is cut into a narrow wedge at the base; b) a slit is made, preferably between the cotyledons, in a germinating seed of the same species; c) the scion is pushed into the seed; d) the union is planted in potting medium and kept moist until either the scion knits with the nurse seed and exists on the latter's roots, or the scion strikes roots or its own, or the graft attempt fails.

When you can't bend the stem to the ground try...

AIR LAYERING

Alan D. Cook

Air layering is also known as marcotting (although there is a difference), Chinese layering, pot layering, circumposition, and, in India, *gootee.*

Both air layering, in which a rooting medium enclosed in a pot or other container is brought to an above-ground stem, and marcotting, in which a rooting medium is bound to the stem, originated in China many centuries ago.

Early air layering involved partial detachment of a long flap of wood from the stem and putting the tip of the flap in soil in a small pot tied to the stem. Marcotting involved moss tied in place. Both methods required frequent watering.

Today's air layering is made enjoyably simpler by the use of plastic film or aluminum foil.

A vertical or horizontal stem from ¼ ″ to as much as 2″ in diameter and from 1 ′-to-3 ′ long is selected and leaves, if any, cleanly removed from a 6″-10″ area. Leaves or leaf-producing buds must be present above the air layer.

The flap method (see Fig. a) is still used, with a piece of toothpick or other barrier holding the wound open so it won't heal back. Because such a cut weakens the stem and may lead to breakage, girdling (see Fig. b) is preferred by many propagators. Bark is completely removed in a ¾ ″ circle on the stem and the exposed wood is scraped gently to remove cambium tissue.

Both techniques result in trapping carbohydrates that otherwise would continue down to the roots. The concentration of food aids root formation. Water uptake through the xylem tissue is unimpeded because xylem is deeper in the stem or trunk than the cambium.

Soak fibrous (unmilled) sphagnum moss (available from many garden stores and mail-order sources) for an hour or more (agitation aids thorough wetting), then squeeze to remove most free water. Surround the stem with a handful or two or more (depending on stem size) at the point of wounding and wrap with plastic, preferably polyethylene. Tie the moss with string (Fig. c).

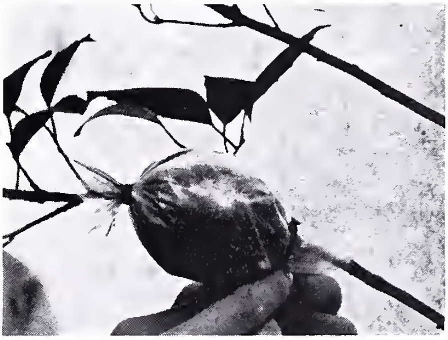
The plastic must extend beyond the wad of moss and be secured tightly above and below with a rubber band, plastic electrical tape, or other binding to keep moisture from evaporating (Fig. d).

Indoors, away from direct sunlight, use clear polyethylene plastic. Out-of-doors use black plastic or aluminum foil (clear plastic traps sun heat.) Experienced operators, as in commercial citrus groves, can deftly crimp foil so it will stay fast without binding for the three months needed for rooting.

Sometimes birds will damage air layer plastic, so foil might be better, or the plastic could be covered with heavy paper.

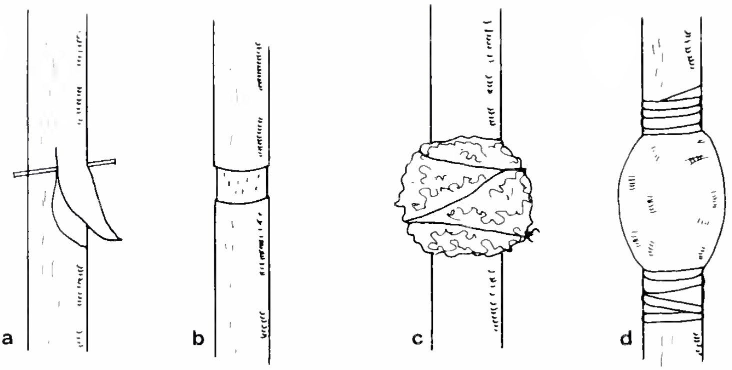
Before and during the rooting process flowers and fruits should be removed from the stems above the air layer.

When roots show through the moss, cut the air-layered stem just below the moss. Remove plastic, leave moss in place, and pot up the new plant or set it out in good



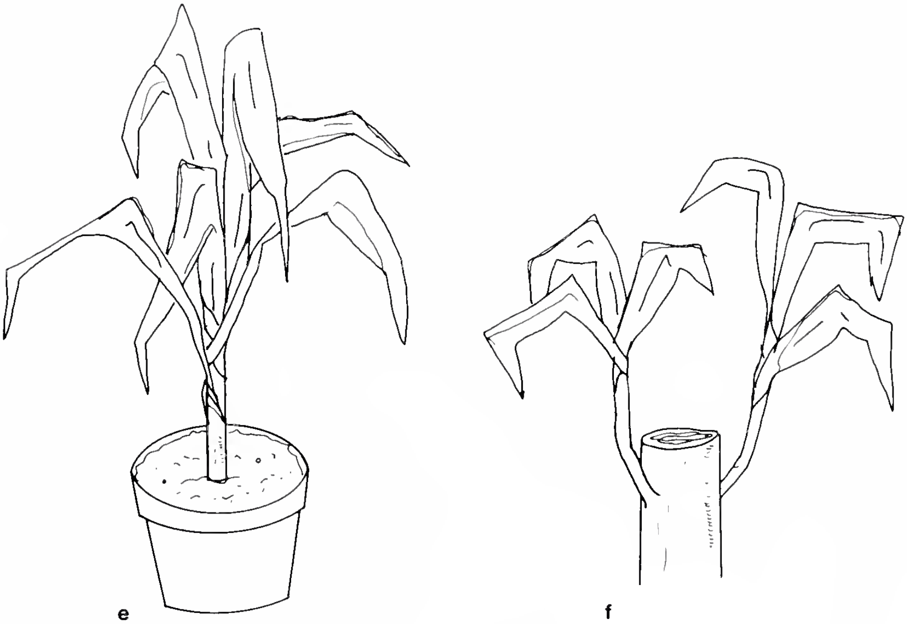
Taylor

The finished sphagnum and plastic wrapped wound, sealed to keep in moisture. Root development will begin and grow into the moss.



K. Kling

a) 1″ flap cut one-fourth of the way into the shoot. Toothpick or twig prevents flap from healing; b) an alternative is to girdle the stem by removing a ½″-wide ring of bark; c) moist, unmilled sphagnum moss placed around the wound and tied loosely with string; d) moss wrapped snugly in polyethylene or foil with top and bottom sealed with tape to conserve moisture; e) new plant removed and potted after rooting; f) after removal of new plant, parent plant sends out new shoots as it would after regular pruning.



soil, and water it copiously. If the new plant is in active growth, shade and/or mist it for a few days to harden it.

Where winter brings freezing temperatures, outdoor air layering should be done in early spring, and new plants removed from the original plant before freezing temperatures set in. Roots are not as hardy as above-ground parts; some will die at 20 °F or even warmer. For house plants or outdoor plants in tropical climates, the process can take place any time. ✤

PROPAGATING HOUSE PLANTS BY CUTTINGS

Kathryn S. Taylor and Thomas Hofmann

There are many ways in which house plants can be propagated, but for many the best method is rooting softwood cuttings. Cuttings can be taken at various times, but early spring (mid-March), when the plants are responding to increasing daylight, is one of the best, as is August. A fairly good guide to readiness is the condition of the stem—it should snap when bent. Sometimes cuttings of fuchsia, lemon-verbena and similar plants are taken too late in the autumn when the tissue has begun to harden. In this case the stem will not snap but crush where it's bent because the wood is too mature. Cuttings made from such wood are apt to be harder to root. Also, cuttings from extremely young, soft tips wilt easily and then root poorly, if at all. Weak and anemic cuttings seldom produce healthy plants.

Of course, cuttings must be free of insects and disease.

Taking Cuttings

To take the cuttings, cut stem tips just below a node with a sharp knife or pruning shears. Sometimes a second stem section may be taken. Cuttings may be 3″-to-5″ long and should contain at least two nodes. Remove bottom leaves, usually only from the lower node, taking care to avoid damaging buds because they will produce stems and hence a bushy plant. If leaves on the cutting are large and space is limited, they can be cut back by a third or even half. Bases of the cuttings may be treated with a mild hormone powder. Be sure to tap away excess powder. Handle cuttings quickly to avoid drying and wilting.

Once made, stick cuttings into a moist, aerated medium and give proper light and heat. This is not always as simple as it sounds—watchfulness is necessary to prevent failure from too much or not enough light, heat or water.

Rooting Media

Two materials have been found good for almost any cuttings. One is perlite, a sterile white material of volcanic origin which holds moisture well but remains better aerated than vermiculite (expanded mica).

H. Gantner

Plastic food box makes a small "greenhouse" environment, useful for starting cuttings.

The other rooting medium is a mixture of equal parts of coarse sand and vermiculite.

Any of the rooting devices discussed on pp. 4–7 will suffice. A polyethylene bag enclosing a properly watered pot or flat of cuttings is one of the easiest. Direct sunlight may overheat the unit, while not enough light will result in spindly growth.

Gentle bottom heat will accelerate rooting. Electric cables or mats are fine but perhaps too bulky for a pot or two. A light bulb under an inverted pan, carefully monitored, can serve nicely.

Special Treatments

Cuttings of cacti and other succulents should be allowed to callus (self-seal the cut surface). Leave them in a shady, dry place for a few days before planting in the rooting medium. They should not be watered until small but definite roots form. Often geranium cuttings also are allowed to dry out for a day or two before planting to discourage fungal and bacterial infections.

The leaves of many succulents and sections cut across the leaves of sansevierias will root if placed upright in damp perlite. Some kalanchoes and bryophyllums will produce new plants spontaneously around the edges of the leaves without the aid of a rooting medium.

Rex begonias are grown from either shoot cuttings or from leaf cuttings. To make these, mature, healthy leaves are chosen. The larger veins are scored on the underside and the leaf pegged down with toothpicks or held down with weights to maintain contact with the damp rooting medium. The leaves must be carefully shaded until rooting takes place at the scores. Another method is to cut a triangular piece of leaf with a bit of its stem attached. This will root if the lower end is set about 1″-deep in the medium. ❧

HOW TO PROPAGATE 101 HOUSE PLANTS

Scientific Name	Common Name	How to Propagate
Abutilon spp.	flowering maple	stem cuttings, seeds
Acorus gramineus 'Variegatus'	variegated sweet flag	division
Adiantum spp.	maiden-hair fern	division, spores
Aechmea spp.	airpine	offsets, suckers
Aeonium spp.		leaf cuttings, offsets
Agapanthus spp.		seeds, division
Aglaonema modestum	Chinese evergreen	stem tip cuttings, air layer
Aloe variegata	Kanniedood aloe	offsets
Amaryllis spp.		seeds (slow), bulbs
Anthericum spp.	spider plant	offsets, division
Anthurium spp.		division, stem cuttings, air layer
Araucaria heterophylla	Norfolk Island pine	stem tip cuttings, shoot cuttings
Ardisia crenata	coral berry	stem tip cuttings, seeds
Asparagus plumosus	asparagus fern	seeds, division
Asparagus sprengeri		seeds, division
Aspidistra elatior	cast-iron plant	division
Asplenium nidus	birds-nest fern	spores
Azalea spp.		stem tip cuttings, seeds, layers
Begonia rex	king begonia	stem tip cuttings, leaf cuttings
Begonia semperflorens	wax begonia	non-flowering stem tip cuttings, seeds
Billbergia spp.		division
Caladium bicolor	elephant's ear	bulbs
Calathea ornata 'Sanderana'	Sanders calathea	division
Camellia japonica		stem tip cuttings
Capsicum frutescens var. *conoides*	tabasco redpepper	seeds
Ceropegia woodii	rosary vine	stem cuttings, aerial tubers
Chlorophytum comosum	spider plant	offsets, runners
Cissus antarctica	kangaroo vine	stem cuttings
Clivia miniata	Kaffir-lily	division
Coleus spp.		stem tip cuttings

HOW TO PROPAGATE 101 HOUSE PLANTS—Continued

Scientific Name	**Common Name**	**How to Propagate**
Crassula arborescens	jade plant	stem tip cuttings, leaf cuttings
Cryptanthus zonatus 'Zebrinus'	zebra plant	offsets
Cyanotis somaliensis	pussy ears	stem cuttings
Cyclamen persicum	florists' cyclamen	seeds
Cyperus alternifolius	umbrella plant	leaf cuttings, division
Dieffenbachia spp.	dumbcane	stem tip cuttings, air layer
Dracaena fragrans		air layer
Dracaena surculosa	spotted dracaena	stem tip cuttings, air layer
Echeveria spp.		leaf cuttings, offsets
Epiphyllum spp.		stem tip cuttings
Epipremnum aureus	pothos	stem cuttings, leaf and bud cuttings
Episcia cupreata	flame violet	leaf cuttings, runners
Euphorbia pulcherrima	poinsettia	stem tip cuttings
Euphorbia milii var. *splendens*	crown-of-thorns	stem tip cuttings
Fatshedera lisei	aralia ivy	stem cuttings
Ficus elastica	rubber plant	leaf cuttings, air layer
Ficus lyrata	fiddle-leaf fig	stem tip cuttings, air layer
Ficus pumila	climbing fig	stem cuttings
Ficus sagittata 'Variegata'	variegated rooting fig	stem cuttings
Fittonia verschaffeltii	silver-nerve	stem cuttings
Fuchsia spp.		stem cuttings
Gardenia spp.		stem tip cuttings
Gasteria hybrida	ox-tongue	offsets
Gynura aurantiaca	velvet plant	stem cuttings
Haworthia spp.	wart plant	offsets
Hedera helix	English ivy	stem cuttings
Hoya carnosa	wax plant	stem cuttings
Impatiens wallerana	touch-me-not, patience plant	stem tip cuttings
Justicia brandegeana	shrimp plant	stem tip cuttings
Kalanchoe blossfeldiana		leaf cuttings, seeds
Kalanchoe daigremontiana	mother-of-thousands	small plants form on leaves
Kalanchoe pinnata	air plant	small plants form on leaves
Kalanchoe tomentosa	pussy ears	leaf cuttings
Lachenalia aloides	Cape cowslip	offsets
Lantana spp.	shrub verbena	stem tip cuttings
Malpighia coccigera	Singapore holly	stem cuttings, seeds
Mammillaria microcarpa	fish-hook mammillaria	seeds, offsets
Maranta leuconeura	prayer plant	stem cuttings, division
M. l. 'Kerchoviana'	rabbit tracks	stem cuttings, division
Monstera deliciosa	ceriman, swiss cheese plant	stem tip cuttings, air layer
Neomarica gracilis	apostle plant	division, new plants from flower shoots
Nephrolepis exaltata 'Bostoniensis'	Boston fern	division, offsets, runners
Notocactus leninghausii	golden ball cactus	seeds, offsets
Oxalis rubra	windowbox oxalis	division
Pandanus veitchii	screw-pine	stem tip cuttings, offsets, suckers
Pelargonium hortorum	zonal or fish geranium	stem cuttings, root cuttings
Pelargonium peltatum	ivy-leaved geranium	stem tip cuttings, root cuttings
Peperomia obtusifolia	oval leaf peperomia	stem cuttings, leaf cuttings
Peperomia argyreia	watermelon peperomia	stem cuttings, leaf cuttings, division
Philodendron scandens subs. *oxycardium*	parlor ivy	stem tip cuttings
Pilea microphylla	artillery plant	seeds, division, stem cuttings
Primula malacoides	fairy primrose	seeds
Pteris cretica 'Albo-lineata'	Cretan brake	division, spores

HOW TO PROPAGATE 101 HOUSE PLANTS—Continued

Scientific Name	Common Name	How to Propagate
Rhododendron spp.	evergreen azaleas	stem tip cuttings, layers
Saintpaulia ionantha	African-violet	leaf cuttings, division
Sansevieria trifasciata	snake plant	leaf cuttings, division
Saxifraga stolonifera	strawberry-geranium	division, runners
Schlumbergera bridgesii	Christmas cactus	stem cuttings
Selaginella uncinata	blue selaginella, peacock moss	stem cuttings
Sempervivum spp.	house-leek	offsets
Senecio hybrids	cineraria	seeds, stem tip cuttings
Sinningia speciosa	gloxinia	leaf cuttings, seeds
Solanum pseudo-capsicum	Jerusalem cherry	seeds, cuttings
Soleirolia soleirolii (Helxine s.)	baby's tears	division
Stapelia grandiflora	carrion flower	seeds, division, stem cuttings (allow to dry)
Syngonium podophyllum	nephthytis	stem cuttings
Tolmiea menziesii	pick-a-back-plant	leaf cuttings, offsets
Tradescantia spp.	spiderwort	stem cuttings
Veltheimia viridifolia		bulbs
Zantedeschia elliottiana	golden calla	seeds, division, bulbs

A piece of polyethylene film
and a bit of sphagnum moss for...

Easy Houseplant Propagation

George Taloumis

Rooting Single Cuttings

A small piece of polyethylene plastic is handy in rooting individual cuttings. Place a small amount of moistened sphagnum moss in a square piece of plastic, and insert the cutting after first dipping the end in a root-promoting powder; then gather and tie the plastic around the stem of the cutting. When roots appear remove the plastic and the cutting can be planted without disturbing it at all.

House plants such as coleus, begonia, African violet, peperomia, shrimp plant, aluminum plant, gardenia and flowering-maple can all be rooted simply and quickly by this method. Geraniums, for example, will root in ten days. The little bundles can be placed on windowsills and other well-lighted places throughout the house where they are out of the way.

Rolling Cuttings in Plastic

Another technique is practical because several cuttings can be rooted in a relatively small unit. Lay out a strip of plastic about 12″-15″ long and 5″ wide and place moist sphagnum moss along the upper half. Then place the cuttings on the moss, with the leafy tips projecting beyond the plastic. Fold the lower part of the plastic up over the stems, roll up the plastic and tie with string.

As many as a dozen cuttings of chrysanthemums, carnations, African violets and many other plants can be handled in this way. The completed units will stand up without pots on a windowsill and will not require additional watering or care until the cuttings have rooted.

Photos by David Leach

PLANT MICROPROPAGATION (TISSUE CULTURE)

James Will

Rooting cuttings, layering, dividing clumps and grafting have been satisfactory methods for clonal propagation of many plants, but there are limitations to these methods. Some plants are hard to root, others cannot be divided. Layering is inefficient and grafting involves much labor and expense and often presents problems with incompatability. Varieties that are difficult to propagate by these methods have been in short supply.

Micropropagation shows promise of overcoming many of these problems. By this method, plant parts are carefully manipulated both chemically and environmentally to force asexual reproduction.

How It's Done

In plant micropropagation, it's necessary to control both the plant environment and the chemical medium. An artificial, or *in vitro*, situation must be created to sustain plant life and cause proliferation of tissue. This environment is provided by sterile vessels containing plant-specific nutrients and growth regulators in a temperature- and light-controlled laboratory. Some plant parts proliferate easily; buds in the leaf axils break with many new shoots arising from each bud. In other plants, an undifferentiated cell mass, called callus, forms first, then differentiates into shoots. There is great variability in the time necessary to propagate different plants through micropropagation, as well as wide variances in yield among species and genera and also different plant parts. Many portions of

Manipulating *Amelanchier laevis* tissue under sterile conditions for further multiplication.

The author above in the Herman Losely & Son micropropagation facilities. Each of the ten shelves with lights can grow as many as 12,500 cuttings. Below left, a laminar-flow hood is necessary for micro-propagation; it allows access to the cultures without contamination. Below right, a culture vessel containing up to forty shoots of the Exbury azalea 'Hotspur'.

plants are used for micropropagation: radish is propagated from inflorescences; hosta, floral scapes; rhododendron, shoot tips and individual florets; and mountain laurel, leaf buds. Herbaceous plants grow quickly in culture; African violets can produce 250 plantlets in about three months from one leaf cutting. Woody plants such as rhododendron take much longer to proliferate and yield less for each plant part used. It takes about six months to produce about thirty plants from one shoot tip.

There are four stages from the time a plant part is placed in culture until it is a rooted plant on its own. The introduction period begins the process, followed by the multiplication stage, the growth stage, and finally rooting. Some plants pass through each stage consecutively; others concurrently multiply and grow, or grow and root. Individual sterile media are prepared for each step, providing the specific chemical formulation necessary for successful micropropagation.

Introduction Stage

The introduction stage of micropropagation involves chemically cleaning the plant part, called the explant, and its initial growth. If the explant is contaminated with bacteria or fungi, the contaminant will compete with the plant for nutrients and generally overwhelm and kill the explant before it can grow. Chlorine bleach at 1:10 normal strength is the most commonly used cleaning agent—usually a ten- to twenty-minute wash is enough to disinfect the tissue. The explant is placed on a nutrient medium containing cytokinin growth regulators that will encourage the buds to break or callus to form. Once there is new growth, the tissue is recultured and multiplied in the second stage.

Multiplication Stage

In this second stage, high levels of nutrients and growth regulators are used to rapidly increase the number of small shoots or the mass of callus. Single shoots of herbaceous plants on a multiplication medium can yield as many as twelve small shoots in two weeks. Once multiplication has occurred and the nutrients in the medium are used up, the plants are moved either to another multiplication medium for further proliferation, or to a new growth medium for development.

Development Stage

With some plants small shoots grow, develop leaves and strengthen their stems while in others callus differentiates into recognizable plant parts. Generally, plant growth media in this stage are low in cytokinins and nutrients but fairly high in auxin growth regulators. The shoots are placed under strong light to encourage photosynthesis.

Rooting: The Final Stage

The propagator has a decision to make for the rooting stage: *in vitro* rooting in the controlled atmosphere of the laboratory or *in vivo* rooting in the greenhouse. *In vitro* rooting uses another sterile medium, with no growth regulators and low levels of nutrients. *In vivo* rooting requires a high-humidity greenhouse and careful control of temperature. Many propagators believe that propagules (plants resulting from micropropagation) are best adapted to *in vivo* conditions at this stage.

Growing

With the increasing popularity of micropropagation, the gardening public will soon join the nursery trade in purchasing and growing microcultured propagules. Some varieties produced by micropropagation have been conventionally propagated for years, so why micropropagate them? These plants will grow continuously, like seedlings, rather than in flushes, like cuttings, and will branch early and from the base and will develop root systems more like seedlings than rooted cuttings.

Growing these cuttings is not difficult. Plant them in a light, peat-based mix, either in a greenhouse or in sheltered rooting frames. Many foliage-plant growers recommend a one-to-one mix of sphagnum peat moss and perlite. Woody plants grow well either in the peat/perlite or in a mixture of 20% sphagnum peat, 20% coarse sand or perlite and 60% aged, shredded pine bark. Often a controlled-release fertilizer can be added to provide continuous nutrition (follow label directions).

After planting, mist the plants often for the first week. After establishment, the plants will need to be watered often enough to keep the medium slightly damp.

As the plants grow, pinch them often to encourage branching. With deciduous material, prune early in the winter to promote sucker formation. The next spring, these suckers will grow and fill out the plant.

Unfortunately, micropropagation will not solve all problems; many plants do not proliferate and complete a growth cycle in culture. But the techniques have brought many plants to the market at a lower cost and at higher quality. Microculture maintains genetic stability—all of the plants produced exhibit the same characteristics. Micropropagation is here to stay.

Helpful Books

Tissue Culture for Plant Propagators by R.A. DeFossard, Dept. of Botany, The University of New England, Armindale, New South Wales 2351, Australia, 1976, gives thorough step-by-step instructions for micropropagation of many plants and also is a good reference for basic cytology and micropropagation-related chemistry.

Plants from Test Tubes; An Introduction to Micropropagation by Lydiane Kyte, Timber Press, P.O. Box 1631, Beaverton, OR 97075, published in 1983, is an elementary guide.

ADDITIONAL RESOURCES—BOOKS AND SUPPLIES

Books

Adriance, Guy W., and Fred R. Brison. *Propagation of Horticultural Plants.* McGraw-Hill Book Company, Inc., NY Third edition 1975.
Hardcover, 298 pp. Nut trees, fruits, bulbs, roses; all methods. Text book.

Arthurs, Kathryn C., and editors of Sunset Books. *Greenhouse Gardening.* Lane Publishing Co., Menlo Park, CA, 1976.
Paperback, 96 pp. A good quick overview of the subject.

Brackern, John. *Your Window Greenhouse.* T.Y. Crowell Co., NY.

Brann, Donald R. *How to Build a Walk-in or Window Greenhouse.* Directions Simplified, Inc., Briarcliff Manor, NY, 1972.
Paperback, 114 pp. Plans for a greenhouse, window greenhouse, and cellar-window hotbed.

Bubel, Nancy. *The Seed-Starter's Handbook.* Rodale Press, Emmaus, PA, 1978.
Hardcover, 363 pp. Vegetables, by seeds.

Clagg, Peter, and Derry Watkins. *The Complete Greenhouse Book: Building and Using Greenhouses from Cold Frames to Solar Structures.* Garden Way Publishing, Charlotte, VT, 1978.
Paperback, 280 pp. The title says it.

Cook, Alan D. "A Propagation Guide," Guest Writer, Special Issues of *"The Avant Gardener,"* Vol. 7, Nos. 1 and 2, 1974. Horticultural Data Processors, Box 489, New York, NY 10028.
Newsletters, 8 pages each. Overview of propagation, all methods. References, sources of equipment and supplies. Reprints available.

Dirr, Michael A. *Manual of Woody Landscape Plants.* Stipes Publishing Company, Champaign, IL, 1975; revised 1983.
Paperback, 826 pp. Hundreds of species and cultivars of trees, shrubs, vines are described, with cultural and propagational notes.

Fisher, Rick and Bill Yanda. *The Food and Heat Producing Solar Greenhouse, Design, Construction and Operation.* John Muir Publications, 1976.
Paperback, 161 pp. A lot of material as per title, but no index.

Fitz, Franklin H. *A Gardener's Guide to Propagating Food Plants.* Charles Scribner's Sons, NY, 1983.
Hardcover 152 pp. Basic how-to on propagation methods.

Fordham, Alfred J. and Leslie J. Spraker. *Propagation Manual of Selected Gymnosperms,* "Arnoldia," Vol. 37, No. 1, 1977. The Arnold Arboretum of Harvard University, Jamaica Plain, MA, 02130.
Paperback, 88 pp. Propagation of common and uncommon cone-bearing plants, all methods.

Foster, Catharine Osgood. *Plants-a-Plenty.* Rodale Press, Inc., Emmaus, PA 18049 1977.
Hardcover, 328 pp. Trees, shrubs, fruits, garden and wild flowers, ferns, vegetables, herbs, house plants; all methods.

Free, Montague. *Plant Propagation in Pictures.* The American Garden Guild, Inc. and Doubleday & Company, Inc., Garden City, NY, 1957.
Hardcover, 250 pp. Trees, shrubs, perennials; all methods.

Garner, R.J. *The Grafter's Handbook.* Oxford University Press, NY, 1958.
Hardcover 260 pp. Woody plants; grafting.

Gorer, Richard. *Growing Plants from Seed.* Faber and Faber Limited, London, 1978.
Paperback, 144 pp. Trees, shrubs, perennials; by seed.

Greenhouse Handbook for the Amateur, P & G Handbook No. 42. Brooklyn Botanic Garden.
Paperback, 96 pp. A series of articles on greenhouse growing, including the cold frame.

Haring, Elda. *The Complete Book of*

Growing Plants from Seed. Hawthorn Books, Inc., NY, 1967.

Paperback, 240 pp. Trees, shrubs, vines, house plants, vegetables, flowers; from seed.

Haring, Elda. *The Seedling Handbook.* American Garden Guild, Garden City, NY, 1968.

Paperback, 48 pp. Annuals, herbs, perennials, weeds; indoor and outdoor seeding.

Hartmann, Hudson T., and Dale E. Koster. *Plant Propagation Principles and Practices.* Prentice-Hall, Inc., Englewood Cliffs, NJ, 1984.

Hardcover, 558 pp. Fruits, trees, shrubs, annuals and perennials, all methods. Lucid, thorough, well-written textbook.

Hills, Lawrence D. *The Propagation of Alpines.* Faber and Faber Limited, London, England. 1950.

Hardcover, 464 pp. Alpines and rock garden plants, 2,500 species mentioned; seeds, cuttings, layers.

Kramer, Jack. *Your Homemade Greenhouse.* Walker and Company, NY, 1975.

Hardcover, 96 pp. Discussion, plans, construction of various glass and plastic greenhouses.

Lapidus, Saul, ed. *The Greenhouse Catalog of Catalogs.* David McKay Company, Inc., NY, 1977.

Paperback 177 pp. Basic information on choosing, building and operating greenhouses. 146 pages of greenhouse dealers and prices (1977), horticultural associations, plant societies, etc.

Loewer, H. Peter. *Seeds and Cuttings.* Walker and Company, NY. 1975.

Paperback, 96 pp. House plants; seeds and cuttings.

Mahlstede, John P. and Ernest S. Haber. *Plant Propagation.* John Wiley & Sons, Inc., NY, 1957.

Hardcover 413 pp. Trees, shrubs, vines, herbaceous perennials; all methods. Textbook.

McDonald, Elvin. *How to Grow Flowers from Seeds.* Van Nostrand Reinhold Company, NY, 1979.

Paperback, 236 pp. Annual, biennial, perennial, and bulbous flowering plants; by seed.

Milstein, Dee and Gene. *Water, Light & Love: A Guide to Growing Plants from Seeds.* Applewood Seed Company, Lakewood, CO, 1976.

Paperback, 96 pp. Wild flowers, herbs, grasses, tropical plants; by seeds.

Nehrling, Arno and Irene. *Propagating House Plants.* Hearthside Press, Inc., Great Neck, NY, 1971.

Hardcover, 292 pp. Houseplants, herbs and vegetables indoors.

Nichols, Richard. *The Handmade Greenhouse, from Windowsill to Backyard.* Running Press, Philadelphia. 1975.

Paperback, 127 pp. Window and free-standing plastic-covered greenhouses, discussion and plans, sources.

Oldale, Adrienne and Peter. *Plant Propagation in Pictures.* David & Charles, North Pomfret, VT. (first published in Great Britain). 1975.

Hardcover, 96 pp. Trees, shrubs, bulbs, perennials, house plants, seeds, division, cuttings; seeds, division cuttings, layering, budding roses.

Pierce, John H. *Greenhouse Grow-How.* Plants Alive Books, Seattle, WA. 1977.

Hardcover, 238 pp. Discussion, plans for cold frame, lean-to and free-standing greenhouses, operation, sources. A chapter on propagation.

Powell, Thomas and Betty. "Glasshouse in a Window," Special Issue of "The Avant Gardener," Vol. 9, No. 23, 1977. Horticultural Data Processors, Box 489, N.Y., NY 10028.

Newsletter, 8 pp. Good discussion of window greenhouses and a list of suppliers.

Powell, Thomas and Betty. "The Golden Age of Greenhouses," Special Issue of "The Avant Gardener," Vol. 3, No. 18, 1971. Horticultural Data Processors, Box 489, N.Y., NY 10028.

Newsletter, 8 pp. A quick look at greenhouse types, styles, construction and heating. Additional reading, sources of blueprints, greenhouses, and supplies.

Powell, Thomas and Betty. "The Solar Greenhouse," "Designing the Solar Greenhouse," and "Active Solar Systems," Special Issues of "The Avant Gardener," Vol. II, Nos. 21, 22, 23, 1979. Horticultural Data Processors, Box 489, N.Y., NY 10028.

Newsletters, 8 pages each. The ins-and-outs of solar structures, active and passive. Sources of information and materials.

Seeds of Woody Plants in the United States. Forest Service, U.S. Dept. of Agriculture, for sale by Supt. of Documents, U.S. Gov't. Printing Office, Washington, DC 1974.

Hardcover 883 pp. Trees and shrubs, native and exotic, from seeds.

Sparry, Joy, et al. *Cuttings Through the Year*. Second Edition, 1966. University of Washington Arboretum, Seattle, WA 98195.

Paperback, 48 pp. Overview of cutting propagation, herbaceous and woody species listed chronologically.

Still, Steven. *Herbaceous Ornamental Plants*, Second Edition. Stipes Publishing Company, Champaign, IL 1982.

Paperback, 303 pp. Annuals, biennials, perennials, bulbs; descriptions include propagation notes.

Tobey, Peter. *Pirating Plants*. Tobey Publishing Co., Inc., New Canaan, CT 1975.

Paperback, 174 pp. Trees, shrubs, perennials, house plants; all methods.

Toogood, Alan. *Propagation.* Stein and Day, 1981.

Hardcover, 320 pp. Trees, shrubs, perennials, houseplants, greenhouse plants; all methods.

Wahlfeldt, Bette Galman. *All About Greenhouses, with 15 Build-Your-Own Plans*. Tab Books, Inc. Blue Ridge Summit, PA. 1981.

Paperback, 463 pp. The title says it.

Walls, Ian. *The Complete Book of Greenhouse Gardening.* Quadrangle/The New York Times Book Co., NY 1973. First published in Great Britain.

Hardcover, 447 pp. Greenhouse selection, building, operation. Two chapters on propagation.

Welch, H.F. *Mist Propagation.* Faber and Faber, London. 1970.

Hardcover, 162 pp. Plants in general, emphasis on misting equipment and operation. One chapter especially for the amateur.

Wells, James S. *Plant Propagation Practices.* The Macmillan Company, NY 1964.

Hardcover, 344 pp. Fifteen selected woody groups (e.g., Japanese maples, rhododendrons and azaleas, camellias, flowering dogwood, hollies, etc.); seeds, cuttings, grafting, layering.

Wright, John I. *Plant Propagation.* Sterling Publishing Co., Inc., NY 1983.

Hardcover, 216 pp. Practical information for the amateur on just about everything concerning propagation.

Wright, John J. *Plant Propagation for the Amateur Gardener.* Blanford Press, England (distributed in U.S. by Sterling Publishing Co., Inc., NY 1983).

Hardcover, 216 pp. Complete range of cultivated plants from vegetables to trees; all methods.

Wright, R.C.M. *The Complete Handbook of Plant Propagation.* Macmillan Publishing Co., Inc., NY 1975 (from British publication 1973).

Hardcover, 191 pp. Fruits, trees, shrubs, annuals, perennials, water plants, bulbs, houseplants; all methods.

Wyman, Donald. *The Arnold Arboretum Garden Book.* D. Van Nostrand Company, Inc. NY 1954.

Hardcover, 354 pp. Many subjects; an excellent chapter on propagation, including a seed collection calendar, seed storage, and an interesting discussion of air layering.

Also of Interest

The federal government and many states issue pamphlets concerning propagation.
Here are samples:

"Air Layering" LF-CP22-79 Cooperative Extension Service, The Ohio State University, 2001 Fyffe Ct., Columbus, OH 43210.

"Budding and Grafting," Extension Circular No. 326. North Carolina Agricultural Extension Service, State College Station, Raleigh, NC 27607.

"Budding and Grafting Fruit Trees." Extension Bulletin 508, Cooperative Extension Service, Michigan State University, East Lansing, MI 48823.

"Building and Using Hotbeds & Cold Frames." Bulletin HO-53 Cooperative Extension Service, Purdue University, Lafayette, IN 47907.

"Home Propagation of Ornamental Trees and Shrubs." Bulletin #80. Plant Science

Research Div., Agricultural Research Service, 1962. For sale by Superintendent of Documents, U.S. Gov't. Printing Office, Washington, DC 20402.

"Intermittent Mist Propagation" Bulletin 573, Cooperative Extension Service, The Ohio State University, Columbus, OH 43210.

"Intermittent Mist Propagation." Circular 506, North Carolina Agricultural Extension Service, State College Station, Raleigh, NC 27607.

"New Shrubs from Old...by Layering," Cornell Extension Bulletin #1006, New York State College of Agriculture, Ithaca, NY 14853.

"Propagating House Plants." Circular #533. The Pennsylvania State University, College of Agriculture, Extension Service, University Park, PA 16802.

"Propagating Shrubs from Cuttings." Bulletin #641, Cooperative Extension Service, University of Georgia, College of Agriculture, Athens, GA 30602.

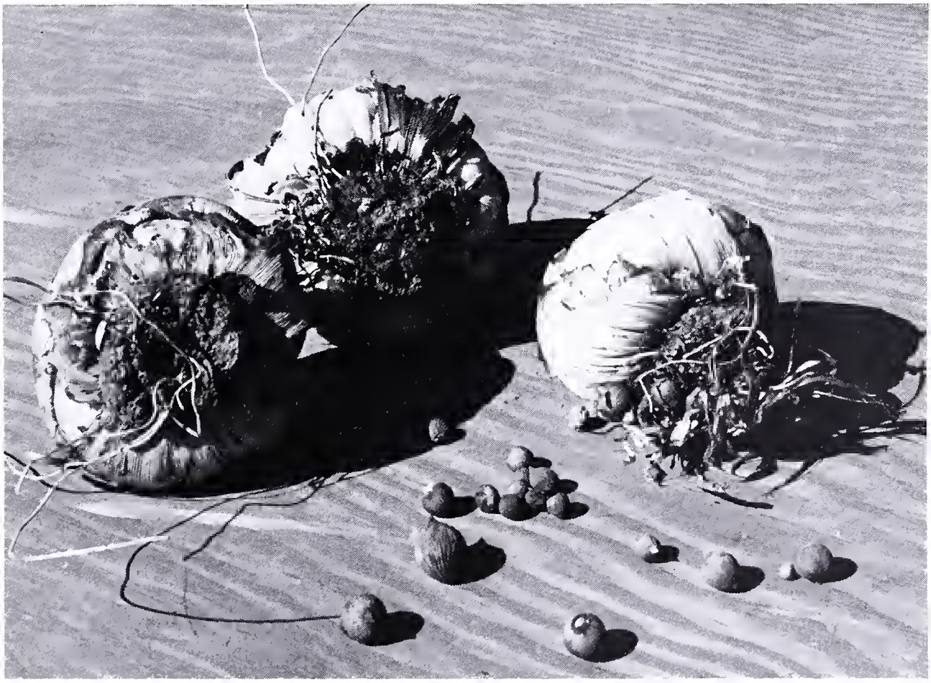
"Propagation by Air Layering." Publication #369, 1970. Extension Division, Virginia Polytechnic Institute, Blacksburg, VA 24061.

"Propagation Unit for Plants." Plan #6101, Miscellaneous Publication #1215, U.S.D.A. For sale by Superintendent of Documents, U.S. Gov't. Printing Office, Washington, DC 20402.

A number of books on specific plant groups also have propagation information.

Plant societies (Cactus, Holly, Lilac, Rhododendron, etc.) through meetings and publications are rich sources of propagation information.

Finally, the advanced grower should know about the yearbook issued by a professional group, the International Plant Propagators' Society. It is called *Combined Proceedings* and includes specialized papers given at annual meetings. Volumes are usually to be found in the larger horticultural libraries.



H. Gantner

Three gladiolus generations: new corm with the old shriveled corm at the base, and separated cormels. Cormels grown for two seasons will become flowering-sized corms.

Some Sources of Propagation Equipment, Tools, and Supplies:

Aquamonitor, Huntington, NY 11743. Mist systems: kits, sensors, controls, etc.

Brighton Horticultural Supplies, P.O. Box 23, New Brighton, PA 15066. Knives, pruners, hormones, pesticides, mist systems, timers, heat cables, soil sterilizers, perlite, vermiculite. Catalog $5.00; $10.00 minimum order.

W. Atlee Burpee Co., Warminster, PA 18974. Seeds, tools, cold frames, media, cubes, pots, lights.

Carolina Biological Supply Co., 2700 York Road, Burlington, NC 27215. Tissue culture kits.

Fantasy Farms Nursery, Box 157, Peck, Idaho 83545. (208) 486-6841. Conifer seedlings.

E.C. Geiger, Box 285, Harleysville, PA 19438. Mist system, plastic films, greenhouse equipment.

Grootendorst Nurseries, Lakeside, Michigan 49116. Rootstocks, normal and dwarfing for apples and other fruits; grafting kits.

A.H. Hummert Seed Company, 2746 Chouteau Ave., St. Louis, MO 63103. Grafting suppliers, hormones, mist supplies.

Lawyer Nursery, 950 Highway 200 West, Plains, MT 59859. Seeds, deciduous and conifer rootstocks. $50 minimum order.

A.M. Leonard, Inc., 6665 Spiker Road, Piqua, OH 45356. High quality knives and pruners, grafting supplies, heating cables and mats, hormones, plastic film.

Mellinger's, Inc., 2310 W. South Range, North Lima, OH 24452. Air layer kits, grafting supplies, heating cables and mats, cubes and pots, seedlings suitable for grafting understocks (deciduous, evergreen, fruit trees including dwarfing), hormones, mist systems, sphagnum moss, timers, perlite, vermiculite, peat moss.

Moss Merchants, 572 Coos River Road, Coos Bay, OR 97420. Sphagnum moss.

Musser Forests, Inc., P.O. Box 340, Indiana, PA 15701. Evergreen (pine, spruce, etc.) and deciduous tree seedlings.

Walter F. Nicke, Box 667G, Hudson, NY 12534. Small propagating units, pruners.

Ohio Association of Garden Clubs, Inc., 4315 Strobridge Road, Vandalia, OH 45377. Mist nozzle on riser, attach to garden hose, $10.00 postpaid.

Geo. W. Park Seed Co., Inc., Cokesbury Road, Greenwood, SC 29647. Seeds, seed starter kits, lights, pots, cubes, heat cables, fungicides, sphagnum moss, cold frames.

Some Greenhouse Manufacturers and Dealers:

Aluminum Greenhouses, Inc., P.O. Box 11087, Cleveland, OH 44111

English Greenhouse Products Corp., 11th and Linden Streets, Camden, NJ 08102

Lord & Burnham, Melville, NY 11747

Ludy Greenhouses, New Madison, OH 45346

National Greenhouse Co., Box 1000, Pana, IL 62557

Rough Brothers, Inc., P.O. Box 16010, Cincinnati, OH 45216

Stearns Greenhouses, 98 Taylor Street, Neponset, Boston, MA 02122

Sturdi-Built Manufacturing Company, 11304 S.W. Boones Ferry Road, Portland, OR 97219

Texas Greenhouse Company, Inc., 2717 St. Louis Ave., Ft. Worth, Texas 76110

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> **he plants it for posterity.**
> **—Alexander Smith**

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BROOKLYN BOTANIC GARDEN RECORD

PLANTS AND THE HOME GARDENER

A Handbook of Garden Botany

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HOW PLANTS WORK—LIGHT, WATER, NUTRITION
DEFENCE AND SURVIVAL
SEEDS, CIRCULATION, PROPAGATION
Bees, Bats, Insects in Pollination
Why There Is Autumn Color
Latin Names Made Painless

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PLANTS & GARDENS
BROOKLYN BOTANIC GARDEN RECORD

PLANTS AND THE HOME GARDENER

A Handbook of Garden Botany

Vol. 40 August 1984 No. 2

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Popular scientific publications are proliferating, a trend that seems to indicate a willingness on the part of the general public to plunge into the arena of "how things work." The subject of this *Plants & Gardens* Handbook, "how *plants* work," is staggering in its complexity. However, Guest Editor Sally Taylor has managed to set priorities, select experts in each area and make the subject matter understandable, readable and enlightening.

Barbara B. Pesch

Editor

FOREWORD

A recent national Gallup survey for *Gardens For All* reported the astounding figures that 42 percent of all American households (35 million) planted gardens for vegetables in 1983. Jack Robinson, president of *Gardens For All*, reports also that the survey showed gardening in first place as an outdoor leisure activity, ranking 6th overall below watching TV, listening to music and going to the movies. Lawn care, flower gardening, taking care of trees and shrubs involved 82 percent of American households. What better moment to bring to the readers of *Plants & Gardens* a concise introduction to Botany, the study of plants.

For twenty years I have been teaching a course in Basic Botany to many students who are never going on to a professional degree in the science, but who love plants. Over and over again, the students share their delight in learning "how plants grow," not just "how to grow plants." Not all botanists are gardeners, it is true, but most gardeners who grow plants successfully have acquired a wealth of knowledge which qualifies them as amateur botanists with "green thumbs." If you question such a good gardener closely, you find that they have learned about plants by close observation and careful attention to the physical needs of the plants.

A good gardener combines sun-loving and shade-loving plants to create a landscape picture which feels and looks right for the location and exposure, intuitively exploiting the genetic differences in plants which enable them to create and store starch under light conditions which are specific to the species of plant. This gardener is knowledgeable about one of the principles of ecology which explains the fit of plants to specific niches in their environment.

Good gardeners understand the principles of how plant form develops as they create a compact shrub by cutting back leggy shoots, pinching the candles on pines, or carefully pruning a tree to miniature size as a bonsai. They recognize nutrient deficiencies in plants, and know how to remedy the problem by use of compost to improve soil fertility.

Good gardeners have a curiosity about the natural world, which is the one indispensable ingredient of a good botanist. This handbook will satisfy your curiosity by enhancing and enlivening the subject of Botany.

Sally L. Taylor

Guest Editor

G. Hampfler/Longwood Gardens

The growing tip of a woody plant.

THE NATURE OF PLANTS

Betty F. Thomson

You could say that a plant is a solar-powered chemical factory using raw materials that are widely, almost universally, distributed over the surface of the earth. Basic to its nature are the most obvious things about a plant: it is green, and it is firmly anchored in the earth.

The greenness resides in that miracle molecule, chlorophyll. The importance of this one kind of molecule to life as we know it is one of those things that truly boggles the mind, and the more one knows about it the more boggling it becomes; for this substance is the sole gateway through which the boundless energy radiating from the sun can enter the entire living world. It has the unique ability to absorb energy in the form of light, convert it to chemical energy and, what is most important, tie it up in the chemical bonds that hold together the atoms of sugar molecules. From there it can be transferred from one kind of substance to another through what may become long and elaborate series of changes until it comes to a chemical dead end and is of no further biological use. It is only on-going photosynthesis that keeps the world from grinding to a halt.

Other raw materials for these manifold transformations come from the air and the earth: from the air, carbon dioxide in gaseous form; from the earth, water and, dissolved in it, a variety of inorganic mineral substances.

J. Fanning

Two steps in the human food chain, vegetable and animal. Virtually all higher animals are directly or indirectly dependent on the energy reserves of plants.

From these sparse materials plants manufacture a vast array of more complex substances, starting with carbohydrates, both simple and complex, proteins and fats. The list also includes vitamins, oils, waxes and other materials man uses as foods, dyes, fibers, poisons, drugs, flavorings and fragrances—all synthesized in the tissues of one kind of plant or another.

After such complicated chemical activities, is there a problem with wastes or leftovers? The leftover from the primary process of photosynthesis is oxygen, which simply diffuses into the air. About other "wastes" botanists have been arguing for generations. It seems that one by one the candidates for plant waste products have turned out to have some physiological function in the plant's life, or at least some plausible survival value for the plant that produces them.

There really is no inherent reason why an organism so completely predicated on its powers of synthesis should have the kind of waste problem that faces an animal. What an animal takes into its body as food consists of large, complex chemical entities in an array that may or may not be closely related to just what its consumer can use. To be of use, the prey or the forage must be completely dismantled, first bite by bite, then right down to its component chemical molecules. This is the function of a digestive system that may be large and elaborate. These materials must then be circulated through the whole organism where they can be absorbed into the tissues. This is the function of the circulatory system, an array of tubing through which blood moves around and around, plus a heart that keeps the grand conveyor system moving. Not everything is absorbed, and the residue plus some of the products of metabolism of the tissues must be disposed of, as well as such solid matter as was never fully digested. All of this is of no significance in the life of a plant.

Being ourselves animals (although we like to think we are not *just* animals) we think of the animal way of doing things as the norm. A plant, however, is *not* an imitation animal but a quite different kind of entity. While there is a wide similarity in the basic needs and activities of all living cells, there is a gross difference in the needs and capacities of the whole organisms of which they are a part.

A creature that is to move around in the world to find its food must be able to function as one compact, self-contained unit. No multiple fluttering leaves, no roots fast in the earth for us. To become such a being we develop one, or one set, of each necessary part and grow to a given size. Then we are finished and on our own for the rest of our lives. Woe betide us when any vital part, a heart or a brain, is severely damaged.

In contrast to this, a plant has no vital organs. Its parts are much less specialized, and so long as it has a leaf in the air, a root in the soil, and a stem to connect them, even a very small plant can do essentially everything that any whole plant of that kind can do. Moreover through all its life a plant continues to grow, producing one after another more stems and leaves, more roots, and in time a number of reproductive or seed bearing structures.

This new growth takes place at the joints or tip of each stem and each root, where a little mass of permanently embryonic tissue, a meristem, lives on indefinitely, forming new tissues that grow into more root, stem, leaf or flower. Moreover, in most plants any still-living tissue can revert to the embryonic state and turn into a meristem, which in turn can produce root, stem, or leaf. If part of a plant is detached, such meristems can produce whatever is needed to reconstitute an entire plant. From this capacity arises the possibility of vegetative propagation, or cloning. By contrast, although you can get a whole flatworm from half of a simply-built flatworm, and a salamander can regenerate a missing limb, you cannot get a whole complex rabbit from a rabbit's foot, or any other part of a rabbit, for that matter.

What about breathing—do plants breathe? Not in the sense of the pumping in and out of masses of air. No heaving chests in the plant kingdom! Rather the ventilation of the plant's interior, the movement of gases in and out of it, is accomplished well enough by simple diffusion, the spontaneous micro-movement of gas molecules, each kind from where there is more of it to where there is less.

As for internal circulation and the coordination of one part with another, there is nothing comparable to a nervous system and no closed system of tubing containing a freely moving fluid or blood. There's not often a crisis that calls for instant reaction in the life of a plant. Messages sent within it can just as well travel relatively slowly and are conveyed by chemical means—hormones or growth regulators.

Although there is nothing like an animal's circulatory system in a plant, there are special provisions for the movement of materials. These are located in the veins of stem, leaf and root. No part of a plant is very far from at least a minute strand of conducting tissue. Water and any substances dissolved in it have a fairly free passage by way of a long series of dead, empty, woody-walled cells known to botanists as xylem (from the Greek word for wood). More complex organic substances travel through a highly specialized kind of cell technically known as phloem (Greek for bark). These cells are living and can control what moves in or out of them and in which direction it will move. We know a good deal about the minute structure and the physiology of these cells, but there is still a lot to be learned before botanists will feel that they really understand how phloem works.

Within the plant, as elsewhere in the world, any material tends to move from where there is more of it to where there is less. Water moves overwhelmingly up the stem and out the leaves. Sugars move from the leaves to all other parts of the plant. Any deviation from this rule requires the expenditure of energy and some form of control by living cells. Here again, while much is known, much more remains to be discovered.

Of reproduction I will say only that it has always been somehow amusing to contemplate the similarities of the whole business between the plants in our gardens and our fellow-animals and mankind, for that matter: the same need to bring together the germ cells, to provide for the needs of the offspring until they can fend for themselves in the world and the same need to see to it that the young get established in a place where they can get a toe-hold and flourish. There are even many parallels in the way all this is accomplished. But in the plant world there is none of the vast social and emotional superstructure that brings such intense joys and sorrows to us.

All this has been a very analytical discussion of the nature of plants. Chemical factories they may be, yet I do not know any botanists, however objectively scientific, who do not take a very human pleasure in dealing with whole plants in field, forest, garden or growth chamber. In our troubled times, happy indeed are those who can immerse at least part of their lives in this serene green world of the plant kingdom.

HOW SEED PLANTS ARE PUT TOGETHER

Lisa M. Baird

The diversity of size, form and structure among seed-producing plants is truly remarkable. Yet for all the variations in form, a basic structural plan is common to all. The plant body consists essentially of a cylindrical axis and lateral appendages. The axis itself is divided into two structurally and functionally distinct units: the stem, which is usually the aerial portion, and the root, usually the underground portion of the axis. Modifications of the basic stem/root plan result in the horizontal underground stems of grasses, in the widening circle of plant offsets of bulbs, in rhizomes, and in the compressed underground stems or aerial roots of orchids. The lateral appendages of a plant may also take on a number of forms. The most common lateral appendages are leaves or modifications of leaves (thorns, spines, tendrils) and hairs.

The Meristem—Where Growth Begins

Growth of plants takes place at discrete regions of actively dividing cells called *meristems.* Meristems are found at the tips of roots and shoots (apical meristems) and just above the point of attachment of a leaf to the stem (intercalary meristem). At these points cells divide and then elongate and mature. This results in growth in height or length of the plant. In many perennials, the activity of an additional set of meristems, the lateral meristems, is responsible for increased girth of the plant and formation of an outer corky layer, the bark.

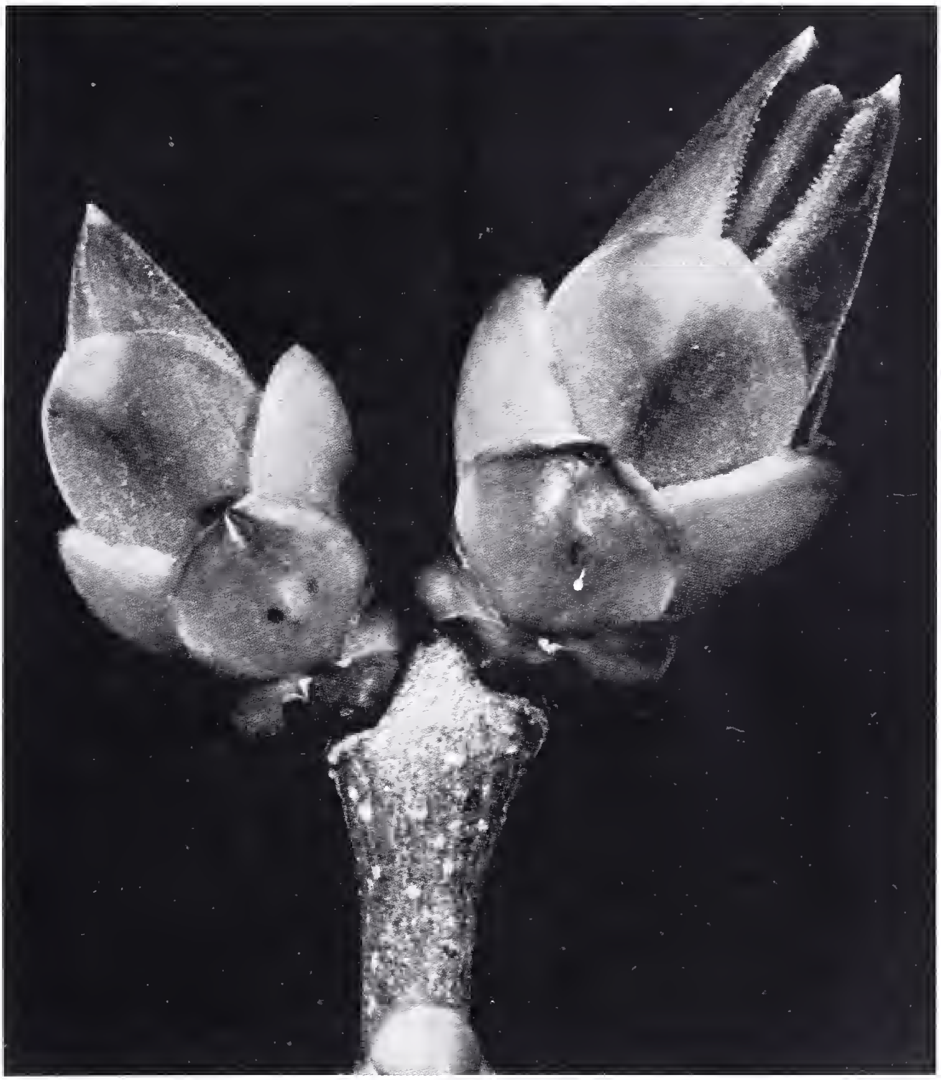
The shoot apical meristem is responsible for the formation of new leaves and buds on the stem. The formation of the leaves, their arrangement on the stem and the shape of the leaf itself are patterned in the meristem and tend to be characteristic of a given plant species. This information is programmed in the plant genes and expressed during plant development. The results are seen, for example, in the characteristic tall, rangy sunflower with evenly spaced leaves and long internodes (the distance between two successive leaves) or head lettuce with large leaves and short internodes, giving it a compact form.

The plant's physiology plus the influence of environment also have a significant impact on the process of plant growth and the final form of the plant body. Any changes in the speed and duration of cell division or elongation usually result in alterations of plant appearance. Light, temperature, availability of water and minerals and the presence of pollutants in the atmosphere can all affect cellular processes and growth in the plant. For example, many trees form small thick leaves on their top branches which are exposed to full sunlight. These leaves are known as sun leaves. On lower branches where the light intensity is reduced, larger, thinner leaves are formed. Such leaves, known as shade leaves, are well suited to utilization of the available light. Many shade-adapted plants which are native to tropical rain forests are very successful houseplants (*Peperomia, Monstera, Dieffenbachia*).

How Form Is Determined

Some plants, such as English ivy, show distinct juvenile and adult shapes of leaves. Often the first-formed leaves are simpler in shape than the mature form, as in bean and morning glory. In plants such as cotton and larkspur, the shapes of juvenile leaves are believed to result from arrested development of a mature, adult leaf form. As the plant gets older, newly-formed leaves develop "completely" resulting in the mature leaf form. As with sun and shade leaves, light appears to be an important factor in the transition of a plant from production of juvenile leaves to the production of adult leaf forms. Lower light intensity favors the maintenance of the juvenile status of the plant.

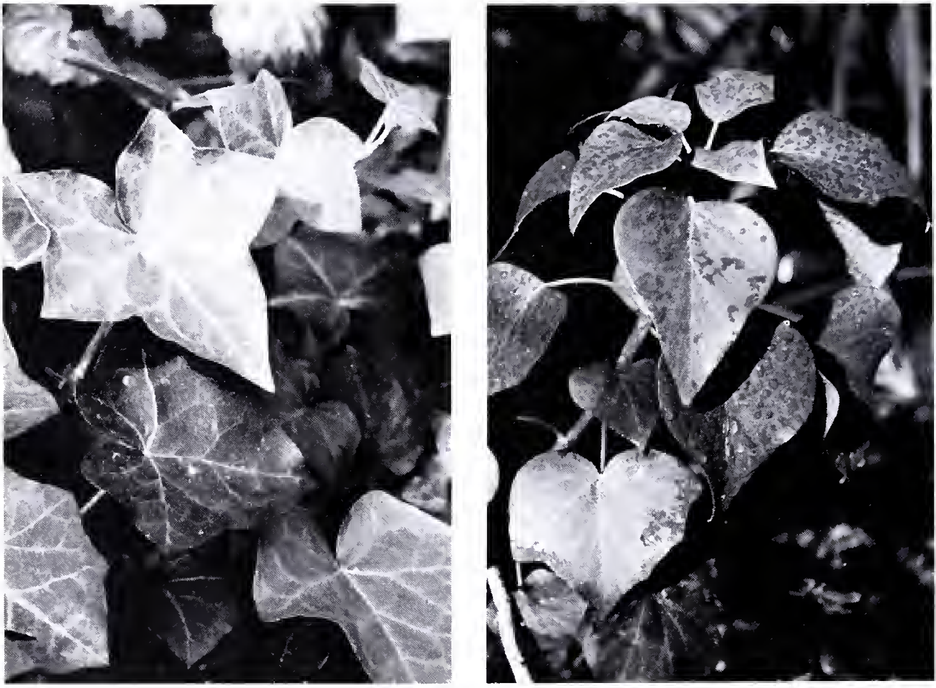
As part of the plant's environment, man can also modify plant growth, appearance or form. Removal of the apical meristems by pruning promotes outgrowth of the intercalary meristems or lateral buds and


W.M. Harlow/Dover

The meristem area contained in the buds of this lilac will eventually expand hundreds of times their current size, developing leaves, flowers, and new buds.

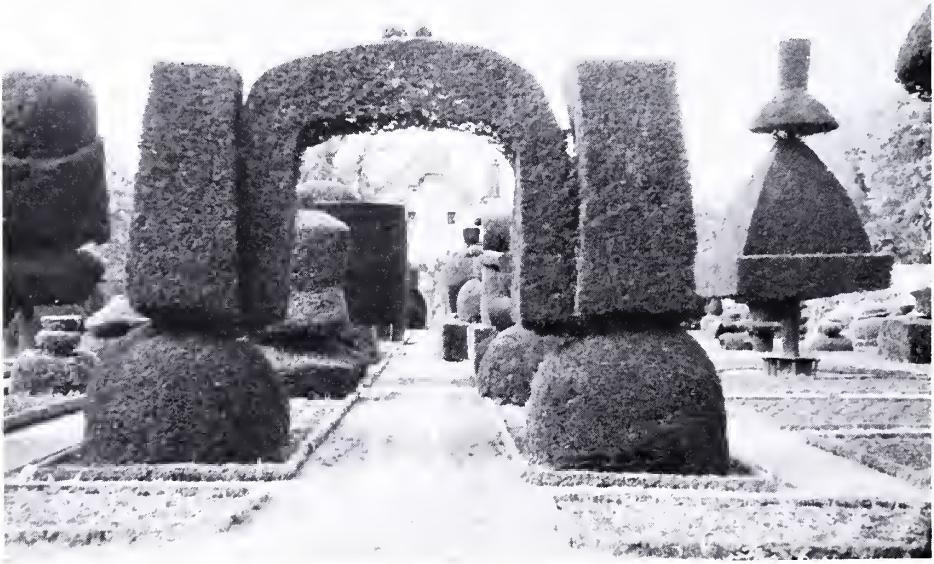
allows one to control plant height, control production of foliage or fruit and to manipulate the appearance of a plant from hedges to topiary. Probably the most striking example of alteration of plant form is the careful, repeated pruning of roots and shoots of trees, shrubs and vines at which the Japanese excel and which results in bonsai-trees in containers or tray-trees (dwarfed potted trees).

Growth of a plant shoot can be determinate or indeterminate. In determinate growth, after a certain period of vegetative growth the shoot apical meristem stops producing leaves and begins to form flower buds. Bush beans and sunflowers are common examples of determinate plants. In indeterminate growth, the shoot apical meristem continues to produce leaves and buds until the plant dies or some environmental factor limits growth. Flowers are produced on buds in leaf axils. Vines and



L. Baird

On the left, the juvenile form of English ivy (*Hedera helix*); on the right, the mature form. English ivy can remain in the juvenile form indefinitely and will if the winter temperature is not moderate enough, as is often true north of New York City.



O.R. Bagett

Fine examples of English topiary, the art of pruning the shoots of woody plants to train the plant into a specific form. Almost any plant can be a topiary subject if it will develop buds or sprout existing buds further back from the point of pruning.

M. Joyner

Above, *Sedum spectabile*, a determinant plant. It is genetically coded to grow to a certain height and no more. Right, *Wisteria sinensis*, an indeterminant vining woody plant that can blanket a tree and then move on.

most trees are examples of indeterminate plants.

Whether a flower is formed at the shoot apical meristem or by axillary buds, the various flower parts are considered to be modified leaves. As with vegetative leaves, the formation of floral "leaves" is both genetically and environmentally controlled. Normally, internal plant controls ensure that a plant will not flower until it has attained sufficient maturity and vigor for reproductive success. Day length (light versus dark periods) may also play a role in inducing flower development. Under environmental stress, such as nitrogen deficiency, flowering and seed set may occur prematurely (regardless of the lack of plant vigor) apparently to ensure even limited reproduction.

Plant form and structure, although genetically programmed and species specific, are highly plastic and responsive to physiological and environmental fine-tuning or manipulation. The simple body plan of an axis and its lateral appendages can be modified in myriad ways, resulting in plants particularly characteristic of and adapted to their environment. ✿

P. Frese

ESSENTIALS OF LIFE: LIGHT, WATER, AND MINERALS

Ruth L. Satter

The development of a seed into a mature plant is a remarkable process. It depends, of course, upon genetic information encoded in the seed. The seed of a dwarf zinnia cannot produce a giant zinnia, no matter how favorable the environment. However, the environment *must* be favorable in order that a plant achieve its full potential. Here we consider how certain aspects of the environment, especially light intensity and daylength, mineral content of the soil and availability of water, affect plant growth.

How Do Plants Use Light?

This question has many answers. First and foremost light provides the energy for plant growth. Green plants convert solar energy to chemical energy by the process called photosynthesis (use of light absorbed by chlorophyll to energize the synthesis of carbohydrates from carbon dioxide and water). The sun emits light of many different colors, including blue, green and red. Chlorophyll absorbs red and blue light very efficiently but absorbs green light poorly. Most of the green is reflected; consequently plants appear green. Fluorescent lamps specially designed for plant growth are rich in red and blue wavelengths and low in green.

The chemical reactions in photosynthesis involve the combination of carbon dioxide (CO_2) and water (H_2O) to form sugars ($C_6H_{12}O_6$), with release of oxygen (O_2). Carbon dioxide enters the plant from the atmosphere through small pores, called stomates, located on leaves and stems, while water is absorbed from the soil by the roots. Much of the sugar formed during photosynthesis is converted to starch, a larger molecule that stores energy for future use. Starch is broken down to smaller carbohydrates as needed; a great deal of the energy stored in these carbohydrates is eventually converted to adenosine triphosphate (ATP), the major energy currency of all organisms. Most of the energy-requiring processes that take place in plant cells are fueled by ATP.

Light and Growth

A plant's need for light of specific intensity is dependent upon the rate at which it utilizes carbohydrates and ATP. Plants that grow rapidly need brighter light than those that grow slowly. Also, plants grown for their fruits or tubers need brighter light than plants grown for their foliage, since fruits and tubers consist mainly of sugars and other carbohydrates, while leaves contain less carbohydrate.

Certain plants grow best in a shaded location. Leaves of philodendron, for example, bleach when grown in bright sunlight because their chlorophyll is destroyed by high intensity light. Impatiens, on the other hand, wilt when grown in bright sunlight because they cannot absorb water rapidly enough to replenish water lost to the atmosphere, particularly if the temperature is high.

The type of shading has important effects on plant growth. A tall building and a tree with dense foliage provide very different types of shade. Let us consider how each of these structures shades two of the colors in sunlight, namely red and far-red light.* While shade created by a tall building contains both red and far-red light, although the intensity of both colors is much lower than in an unshaded area, the shade created by a tree with dense foliage has hardly any red light, but has almost as much far-red light as an unshaded area. The latter occurs because chlorophyll in the leaves of the tree absorbs red light very efficiently, but does not absorb far-red. Plants contain minute quantities of a pigment called phytochrome that senses the relative amounts of red and

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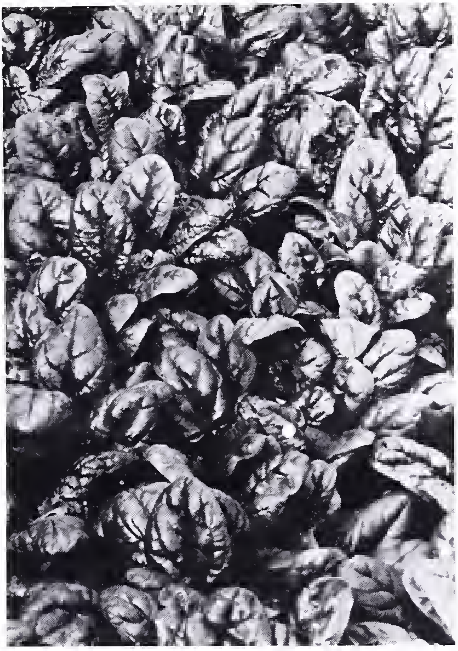
*Far-red light consists of wavelengths slightly longer than those in red light. Humans can barely see far-red light but plants are very sensitive to it.



National Garden Bureau

Fig. 1. Flowering in spinach (left) and lettuce is triggered by long days and short nights. Early planting for early harvest is important to avoid flowering, or "bolting," as it is known.

far-red light and adjusts growth patterns accordingly; in many plants very little red as compared to far-red promotes tall, thin stems and small leaves. This growth pattern helps young plants in a forest grow tall enough to penetrate through the shading vegetation and thereby gain access to full sunlight.

Light and Flowering

Light has still another important effect on plant growth and development. The lengths of the light and dark portions of each 24-hour day vary from 9 hours light and 15 hours darkness in late December to 15 hours light and 9 hours darkness in late June (at the latitude of the Brooklyn Botanic Garden). Plants respond to changes in day and night length which trigger in the plants various developmental processes so that they occur at the appropriate season. Some plants, such as spinach, flower in midsummer when days are long and nights are short (Fig. 1); other plants, such as asters, flower in the autumn when days are short and nights are long (Fig. 2). Variations in day and night length trigger reactions in many hardwood trees, beginning adaptations for the coming winter. Such preparation starts in late summer, when the trees start to produce small, thickened bud scales that are covered by a varnishlike substance that provides thermal insulation. Later in the season, they start accumulating substances with antifreeze properties to protect their cells from freezing injury.

Although measurement of day and night length is called photoperiodism (photo = light), length of the uninterrupted dark period is more important than length of the uninterrupted light period. Light of very

Roche

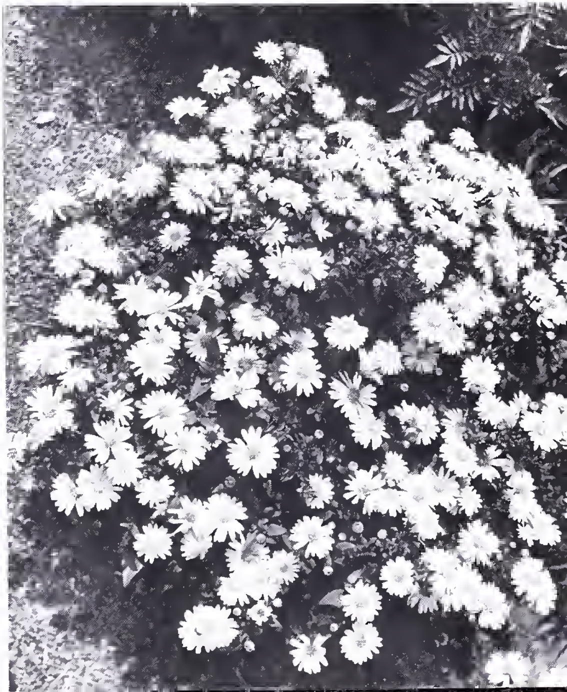
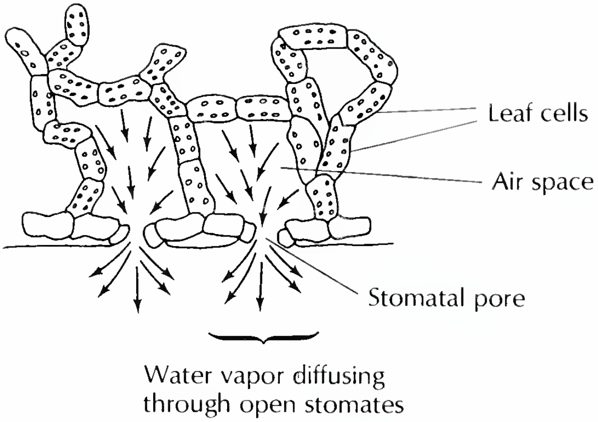


Fig. 2. Asters and chrysanthemums are short day plants that bloom in autumn when nights are lengthening. The aster at right, 'Mauve Cushion', is one of the classic Michaelmas daisies.



K. Kling

Fig. 3. The arrows show the path followed by water vapor diffusing from air spaces in the surface of a leaf through open stomates to the atmosphere where the concentration of water vapor is less.

low intensity that interrupts the otherwise dark period can disrupt time measurement in many photoperiod-sensitive plants. Poinsettias are particularly susceptible; a commercial grower reported that his crop failed to flower for Christmas one year because a conscientious night watchman used a flashlight each midnight to search for flowers in the greenhouse.

How Do Plants Use and Conserve Water?

Water is the main constituent of most plant cells. Carrot roots are about 85 percent water, while the inner leaves of lettuce may be 95 percent water. Much of the water in mature plant cells is contained in a membrane-enclosed storage tank called a vacuole that occupies most of the cell volume. Infusion of water into the vacuole is the main reason for increase in size of the plant cell during growth.

Water is the medium through which the minerals necessary for growth and the sugars produced during photosynthesis are transported throughout the plant. It is also a constituent of many biochemical reactions. It supplies the hydrogen that combines with carbon dioxide to form sugars during photosynthesis. It is also involved in the chemical reaction for synthesis of ATP.

Lack of sufficient water leads to death of the plant. Plants protect themselves from dehydration by coating their outermost cells with a waxy substance called cutin. Hardly any water can permeate through cutin, although microscopic pores called *stomates* create breaks in the cutin layer. These pores permit carbon dioxide (CO_2) to enter the leaf for photosynthesis; loss of water vapor from the plant to the atmosphere through transpiration (evaporation from leaves and stems) is an inevitable consequence (Fig. 3). This water loss is enormous. A single corn plant may absorb a ton of water during a growing season and lose 99% of it to the atmosphere through transpiration. High temperature, windiness, and low relative humidity all promote high rates of transpiration.

Despite the large amount of water given off through transpiration, plants have an effective method for minimizing unnecessary water loss. The stomatal pores change in size in accord with changes in environmental conditions. The pores generally become large (stomates open) in the light when CO_2 is required for photosynthesis, and the pores disappear (stomates close) in the dark, when photosynthesis ceases. However, stomates close at midday on very hot sunny days when the plant cannot take up water from the soil rapidly enough to replace the large amounts lost through transpiration, and they remain closed most of the day when the soil is dry and the rate of water uptake is low. This helps the plant survive during periods of drought, but at a price. The plant grows slowly when stomates are closed, since low levels of CO_2 within the leaf limit the rate of photosynthesis. If a drought is sufficiently severe that the plant cannot extract any water from the soil, the plant dies.

Plants differ in their ability to survive in areas with limited rainfall. Certain plants thrive in the desert. Seeds of some desert-dwelling annuals remain dormant until a prolonged rainfall. The seed then germinates and the plant grows rapidly, completing its life cycle before the soil dries. Many succulents have small, thick, heavily cutinized leaves with relatively few stomates which are located in sunken regions of the leaf surface. This type of structure minimizes water loss through transpiration. *Bryophyllum* is a succulent with still another method for minimizing water loss. Its stomates open at night when rates of transpiration are low, and close during the day when rates of transpiration are high. Carbon dioxide is taken up during the night and stored within the leaf for use in photosynthesis the following day.

What Minerals Do Plants Need?

In addition to water absorbed from the soil and carbohydrates produced during photosynthesis, plants require a variety of mineral elements. Seventeen different elements are considered essential. They are: carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, zinc, molybdenum, copper, boron, chlorine, and nickel. The first four are derived from water and atmospheric CO_2 and, to some degree, atmospheric nitrogen, while the remaining are derived from the rock that gave rise to the soil. Plants require large quantities of some elements but only trace amounts of others. All are essential, however. A deficiency of any of the seventeen can retard growth severely.

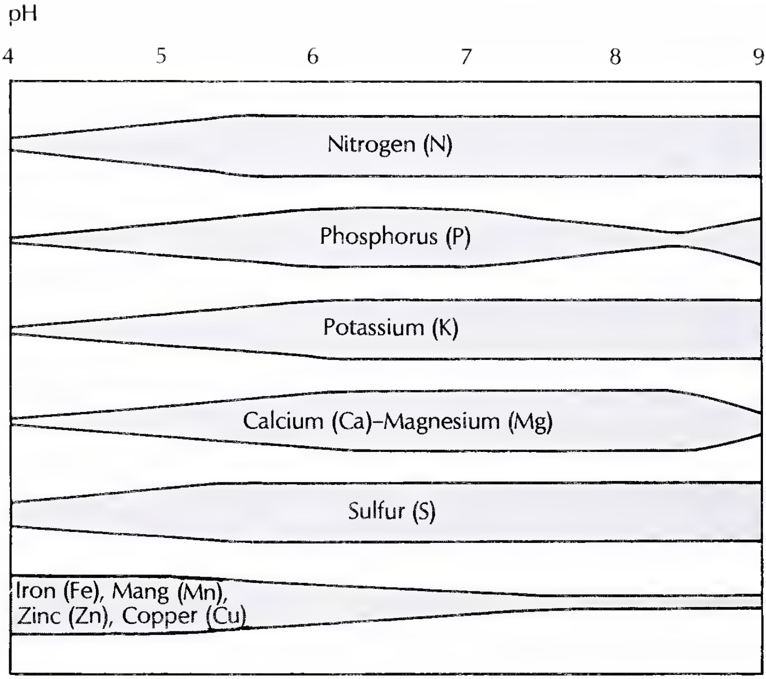
Oxygen, carbon dioxide, and water diffuse freely through stomatal pores on leaves and stems, as we already mentioned. All of the other elements (and some oxygen) are absorbed by the roots. Roots grow continuously, penetrating new areas of soil and removing minerals from these regions. Mineral absorption takes place in hairlike appendages, called root hairs, that are located near the tips of the main root and its branches. The minerals then travel through many layers of cells to the xylem, longitudinal pipes located near the center of the root. Minerals and water travel through the xylem from the roots to the stems, leaves and flowers.

Most minerals have several different functions. Consider phosphorus, for example. It is incorporated into DNA, the substance that carries the genetic information of the cell, and into RNA, the substance that transcribes information from DNA so that it can be used for regulating cell development. Phosphorus is also incorporated into the membranes that surround each cell and each sub-cellular compartment. In addition, it is incorporated into high-energy molecules such as ATP, the medium of energy exchange in all cells.

How Minerals Behave in the Soil

Nitrogen, phosphorus and potassium are depleted from the soil most rapidly by plants, and thus must be replenished regularly. These three minerals are the main ingredients in most commercial fertilizers. The percent of each is listed on the container: e.g., 10-6-4 fertilizer contains 10% nitrogen, 6% phosphorus, and 4% potassium. However, plants can exhibit deficiency symptoms even though the soil contains adequate amounts of all the essential elements derived from rock. This may occur if the soil is waterlogged and adequate oxygen is not available in the vicinity of the roots, since oxygen is required for the efficient production of ATP, the fuel that powers mineral uptake.

Deficiency symptoms may also occur if the soil is too acid or too alkaline (also known as too basic). Acidity and alkalinity are measured by pH, the concentration of free hydrogen (H^+) ions. The higher the concentration, the lower the pH. [The pH scale is logarithmic, that is, a jump from 6.0 to 7.0 is a jump of ten, while 5.0 to 7.0 is a jump of 100, or ten times ten—*Ed.*] When the soil is basic (pH higher than 7.0), certain elements such as iron, manganese, and zinc are poorly soluble and therefore not available in quantity to plant roots. On the other hand, when the soil is very acid (pH below 5.0), these elements may be available or at



K. Kling

Nutrients have differing availabilities at different levels of pH. Although individual plants have varying pH requirements, for many a pH of 6.5 is optimal.

toxic levels to the plants. In addition, H^+ ions are so plentiful at low pH that they displace calcium (Ca^{++}) and other positively charged elements from sites on soil particles. When minerals are free in the soil rather than attached to soil particles, they tend to be washed out of the upper soil layers to very deep layers, thereby creating nutrient deficiencies in the upper layers. Most plants grow better in a soil pH between 6.0 and 6.9, but rhododendrons and many other broad-leaved evergreens grow best when the pH is between 4.0 and 5.0, while beans and other legumes grow best when the pH is slightly higher than 7.0. Preference for a specific pH is determined by two considerations: the plant's need for large amounts of those minerals whose availability is dependent upon pH, and the plant's susceptibility to iron, zinc and manganese toxicity.

Unless they are derived from a limestone base, soils that support vegetation tend to become more acid with time, since plants secrete more H^+ ions into the soil than they take up. Addition of crushed lime or crushed dolomite makes the soil more alkaline; both products replenish calcium, while dolomite also replenishes magnesium.

Although all plants need adequate light, water and minerals for their growth and development, different plants have very different requirements. Some plants grow best in bright sunlight and others in the shade; some grow best in the desert and others in a moist atmosphere; some grow best when the soil is acid and others when it is alkaline. The wise gardener will learn the specific requirements of individual plants and try to provide each plant with the type of environment it prefers.

Suggested Reading

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THE PRIMARY ELEMENT: NITROGEN

Daniel C. Wright

The success of American agriculture can be attributed to the intensive use of fertilizers, especially nitrogen. As described in the previous article, nitrogen is one of the major nutrients a plant needs in order to grow. A plant soon ceases growth, becomes stunted, and eventually dies if nitrogen in the soil is lacking. Conversely, the addition of nitrogen can cause great increases in growth and yield. However, one of the causes of today's increasing cost of food is the also increasing cost of synthetic nitrogen fertilizers. The future success of agriculture is dependent upon farmers and gardeners understanding better how plants get and use nitrogen.

All plant parts, especially seeds, contain nitrogen in the form of proteins. When a portion of a plant is harvested, some of the nitrogen which was originally available in the soil to that plant is removed. Consequently, almost every year, farmers and gardeners must add more nitrogen to the depleted soil to ensure continued crop production or garden success in future years.

Replenishing Lost Nitrogen

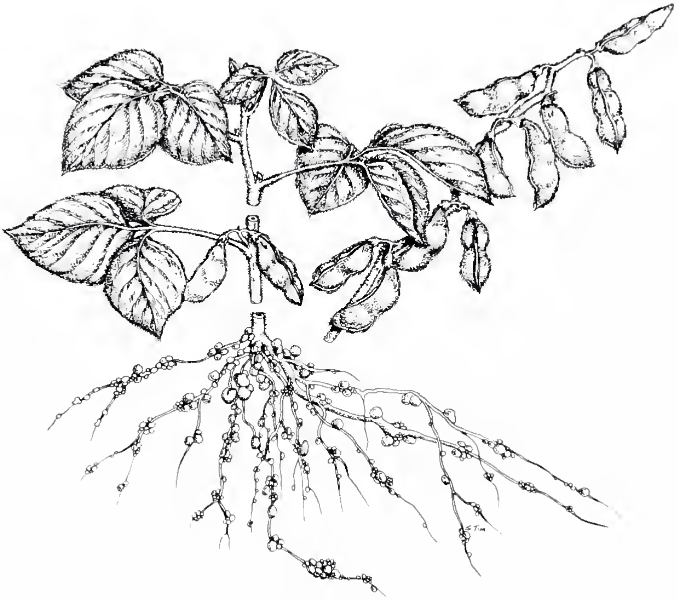
Nitrogen can be returned to the soil in several different forms. Historically, primitive people, and increasing numbers of today's gardeners, return nitrogen to the soil by composting decaying organic material such as leaves, fish parts and other waste products which contain proteinaceous material. The action of bacteria converts this organic nitrogen into ammonia and eventually nitrate which is termed inorganic nitrogen. Only a few groups of plants can make use of organic nitrogen directly; most require nitrogen in its inorganic forms.

Inorganic nitrogen-based fertilizers are available commercially and are essentially formulations of potassium nitrate (saltpeter) and phosphate plus other minerals. The notations on the label of a bag or box of fertilizer, such as 5-10-5 or 14-14-14, refer to the relative percentage on the basis of weight of nitrate, phosphate and potassium. This kind of fertilizer is mined from mineral deposits of ancient marine organisms and their wastes and, like fossil fuels, they are rapidly being exhausted.

In many cases, large-scale gardening systems such as farms use synthetic nitrogen for their fertilizer needs. It is possible to produce ammonia from atmospheric nitrogen gas, a rather inert substance, by heating it to 500 °C under 1000 atmospheres of pressure in the presence of hydrogen gas and a catalyst. The process, called the Haber Process, understandably requires a high input of fossil fuel energy which, in itself, is becoming more expensive to use. The advantage to using ammonia as a fertilizer is that it can be sprayed or injected into the soil quickly. Ammonia also has the tendency to "sweeten," at least temporarily, an otherwise acid soil.

Nitrogen Fixation

Another method by which plants can obtain nitrogen is with the help of certain species of bacteria and fungi which have the capability of "fixing" atmospheric nitrogen. The atmosphere is approximately 80 percent nitrogen gas (N_2); however, nitrogen gas cannot be used directly by plants. Some species of plants have evolved an association with certain species of bacteria to the mutual benefit of both. This association between two different organisms is termed symbiosis. Symbiotic associations between leguminous (Pea Family) plants and species of bacteria of the genus *Rhizobium* have been studied intensely for the past several years because of the importance of these crop plants in agriculture. Symbiotic nitrogen fixers have also been discovered to occur in over one hundred nonleguminous species of plants. In addition, many free-living forms of bacteria, blue-green algae, yeasts and actinomycetes have been found



S.K-M. Tim

Fig. 1. A representative member of the Legume or Pea Family, soybean (*Glycine max*) has the nitrogen-fixing root nodules that, in association with a bacterium, converts atmospheric nitrogen for the plant's and subsequent plants' use.

capable of nitrogen fixation. It has been estimated that over 100 million tons of atmospheric nitrogen are transformed into ammonia annually by the action of symbiotic and free-living nitrogen fixers.

Root Nodules and Nitrogen Fixers

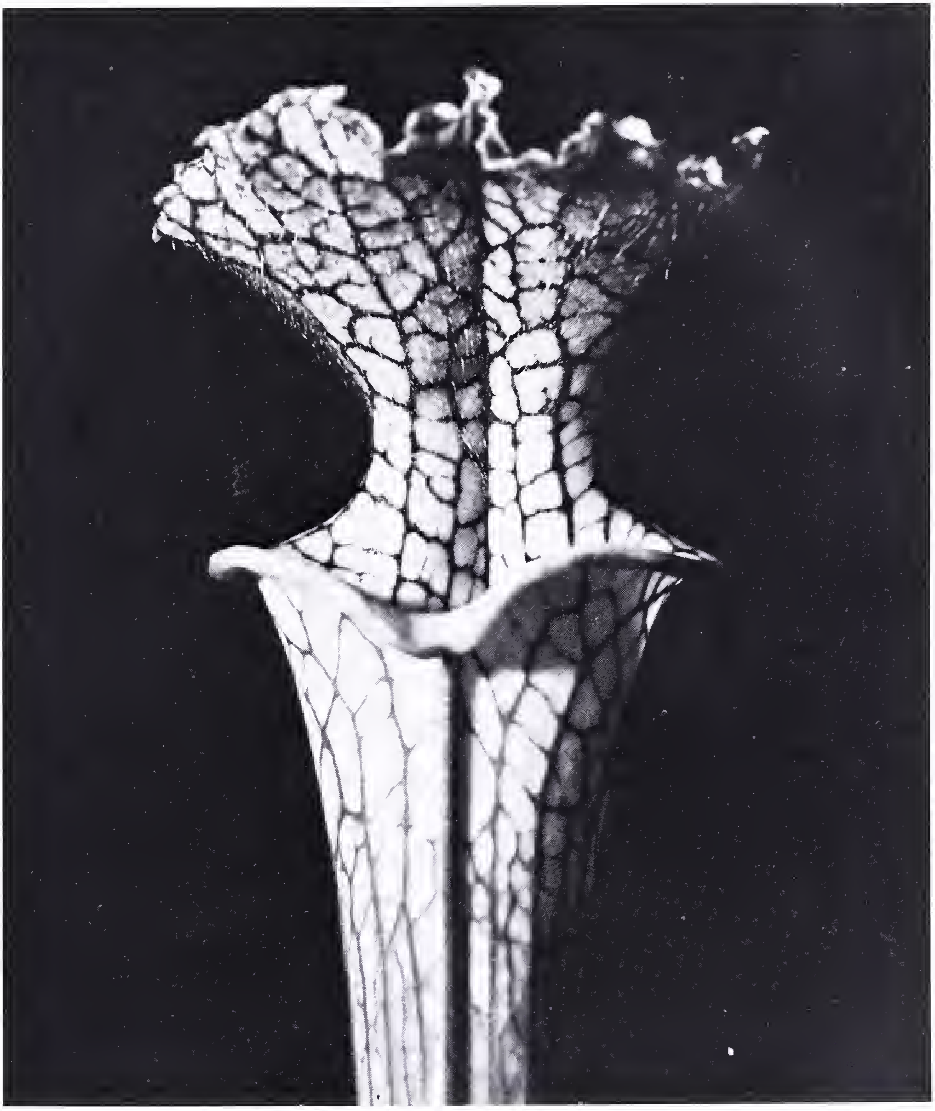
The symbiotic relationship between legumes and *Rhizobium* species occurs in a series of steps beginning with the infection (in this case beneficial) of legume root hairs by the bacteria, the end result being the creation of a root nodule. Within the root nodules containing the bacteria, an environment is created which permits nitrogen fixation to occur. The nodules also contain a substance, leghaemoglobin, similar to the blood hemoglobin of animals. In fact, if a legume root nodule is squashed, this red pigment will have the appearance of blood. In return for the products of photosynthesis (carbohydrates and hydrocarbons), the symbiotic *Rhizobium* provides ammonia which is rapidly converted into amino acids and proteins by its host plants. One of the reasons current agricultural practice recommends rotation of such crop species as corn with a leguminous species is because a legume crop returns nitrogen to the soil that a corn crop removes.

Many different species of nitrogen fixing organisms exist in the world which have not been fully investigated. Perhaps a nitrogen fixer capable of living symbiotically with corn has yet to be discovered. More exciting is the possibility of genetically altered corn or *Rhizobium* resulting in corn that can fix its own nitrogen. Many of today's emerging biotechnologies, such as cloning, recombinant DNA, protoplast fusion and micropropagation, will eventually make such an idea possible but at present considerable research needs to be done.

Parasitic and Carnivorous Plants

A rather small group of plants can obtain a portion of its nitrogen needs directly from other living organisms. This group consists of parasitic and carnivorous plants. Mistletoe (*Viscum* spp. and *Phoradendron* spp.), for example, obtains all of its mineral nutrients, including nitrogen, directly from a host plant. Many other species of parasitic plants exist in nature, including dodder (*Cuscuta* spp.) and witchweed (*Striga* spp.) which are not photosynthetic, depending on host plants for all of their nutritional needs. Carnivorous plants are unique because they supplement their intake of inorganic nitrogen with amino acids and proteins from captured, digested animal (usually insect) prey.

Several methods of capturing animals have been developed by plants including pitfalls, snares and adhesives. Pitcher



Photos by Steven A. Frowine/Missouri Botanic Garden

Fig. 2. The pitfall method of trapping mineral-rich insects is utilized by *Sarracenia leucophylla*, a type of pitcher plant.

plants (*Heliamphora* spp., *Sarracenia* spp., *Darlingtonia* spp. and others) make use of a pitfall type of trap (Fig. 2) in which insects are caught in a pitcherlike structure often lined with downward-pointing hairs containing water laced with insecticidal substances. The Venus flytrap (*Dionaea muscipula*) actively snares small insects with specialized leaves which bears striking similarity both in appearance and action to a bear trap (Fig. 3). Sundews (*Drosera* spp.) make use of a sticky adhesive held on tentaclelike structures which move in response to tactile stimuli to facilitate the digestion of the plant's victim (Fig. 4).

One common misconception about carnivorous plants concerns their need to trap and consume animals. These plants, properly fertilized and given sufficient light, will survive quite nicely without ever needing raw meat or animal protein. Their prey only supplements the nitrogen that is

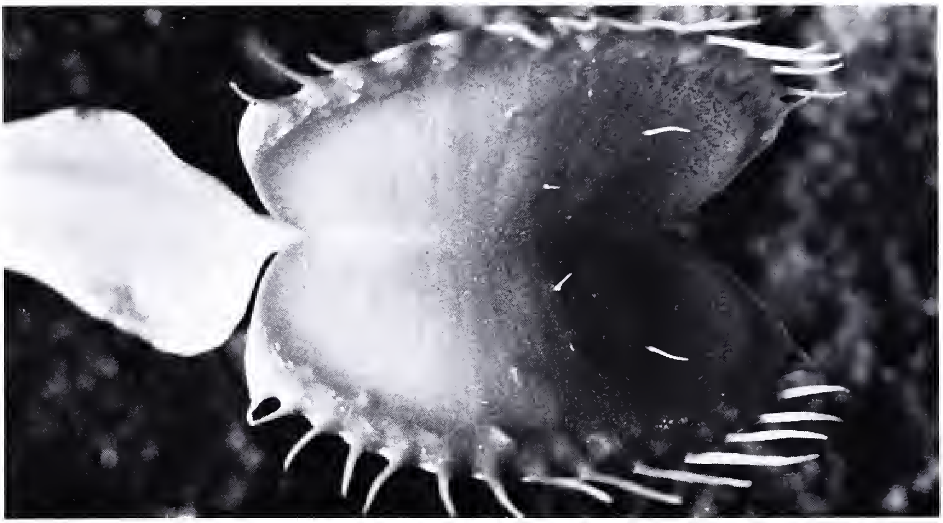
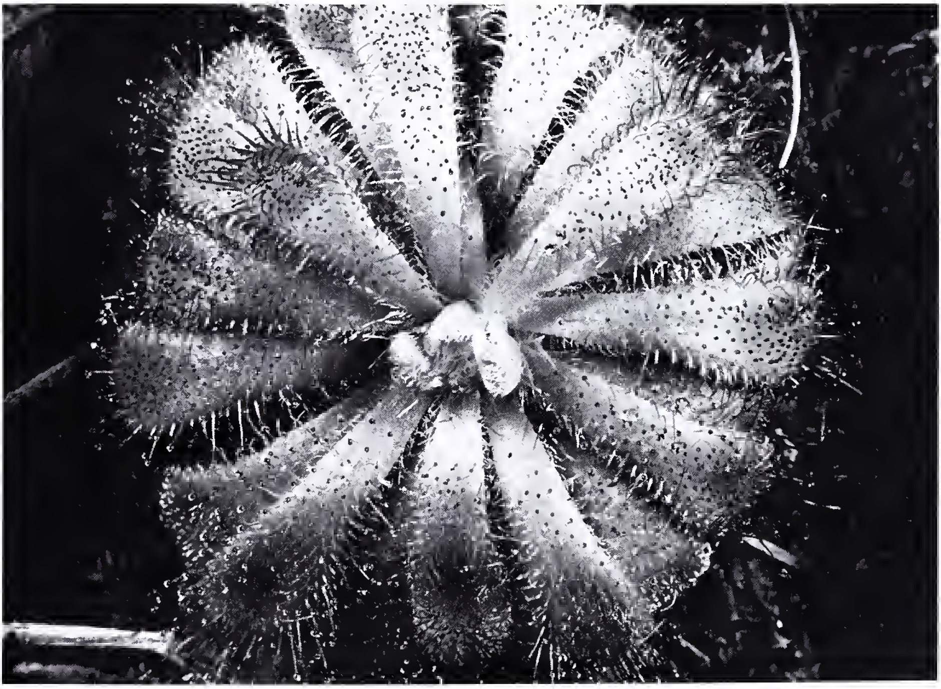
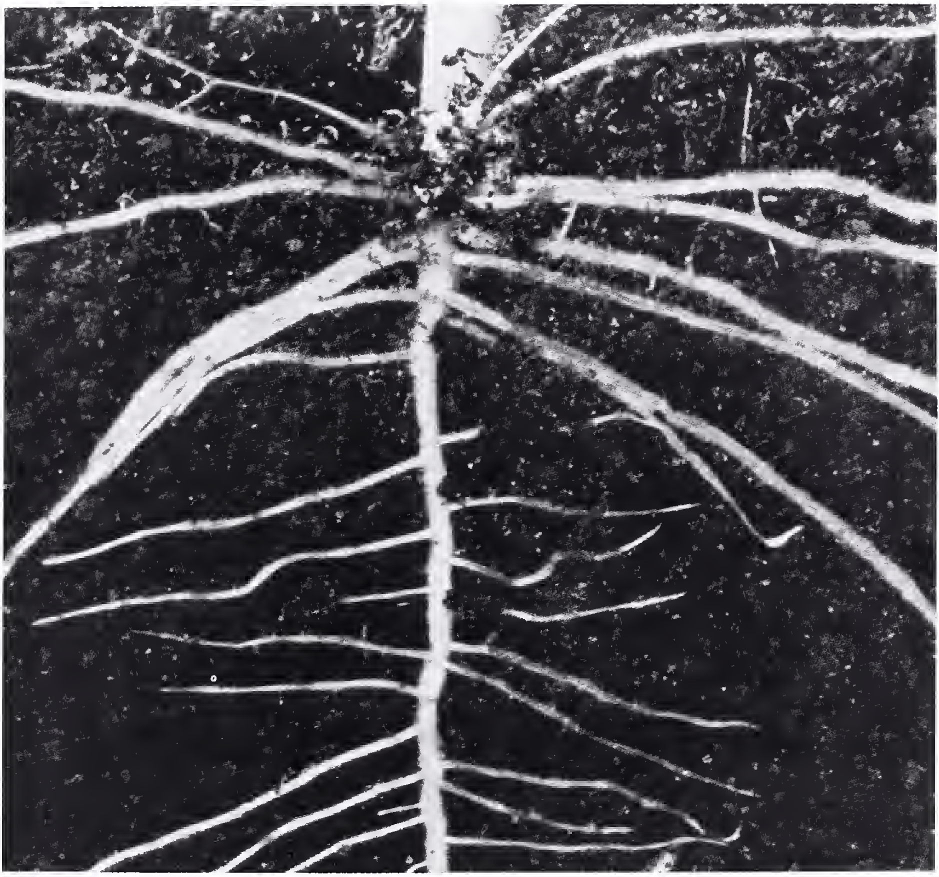


Fig. 3. The Venus flytrap *(Dionaea muscipula)* reacts chemically to the pressure of an insect by closing around it. Fig. 4. The sundews use adhesive tentacles to trap insects as seen below in *Drosera spathulata*.



normally gained through their root systems.

By understanding how some plants make more efficient use of nitrogen than others and how some agricultural systems can be "fine-tuned" in regard to mineral and nitrogen nutrition, farmers and gardeners alike will be able to produce more food more efficiently. As the world's population grows and fossil fuels disappear, this understanding will increase in importance. ✤



Photos by W.M. Harlow/Dover

Taproot and lateral roots of the garden bean. These in turn are covered with tiny root hairs, sites of water and mineral absorption.

THE LEAF'S PLUMBING

Richard M. Klein

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When a pipe breaks in a home or an apartment, we suddenly realize just how dependent modern North American society is upon its plumbing systems. Plants, too, depend upon an intricate piping system to move liquids.

The early plant invaders of the land, some algae and the ancestors of mosses and liverworts, were appressed to the moist bosom of Mother Earth. This meant that water and dissolved minerals didn't have to move long distances from the soil into the photosynthetic tissues, and the sugars formed in photosynthesis had to be transported only a few centimeters to supply food to the non-green cells. As plants began to exploit the various land habitats, they gradually became upright with stems that eventually, as in giants like redwoods, rose well over a hundred meters into the air. Since the distance between the point of water supply and the place where the water was used was so long, the simple movement of water from cell to cell would have been just too slow.

In order to exploit the land fully, a whole series of new plant structures had to develop. Roots probed the soil for water and minerals and became anchors and supports for vertical stems. As seen in fossils, the roots of early land plants developed relatively primitive plumbing systems that ramified into the stem and its flattened, photosynthetic branch tips. Eventually, these veins extended into the leaves, which were modified branches. Ferns and the allied horsetails and ground pines were fully plumbed and the engineering efficiency of these liquid-transmitting systems permitted the evolution of giant tree ferns, cycads and gymnosperms and the development of the flowering plants.

The leaf is a most elegant structural and functional solution to several difficult problems of getting along in this world. If a plant is to capture sunlight efficiently, the chlorophyll-containing tissues should have maximum surface area—a characteristic of the flattened leaf. By having almost uncountable numbers of leaves precisely arranged about a stem or branch, each of the leaves will be exposed to sunlight. What remained to be worked out by evolutionary interactions between organism and environment was some way of connecting the plumbing system of the root and stem with that of the leaf, not only to get water and minerals into the leaf, but also to move sugars formed in the leaf the long distances to the lower stem and the root system.

To some extent, we can visualize the process by which evolutionary changes that resulted in the leaf plumbing system developed by following the growth of the leaf. The leaf is initiated as a small bulge of cells on the side of the stem tip. As this bulge increases in size and in cell numbers, and even before it looks much like a leaf, some of the cells in the mass begin to elongate more than their neighbors, some develop spiral thickenings of cellulose around their walls, and cell contents disappear and their endwalls dissolve, thus forming a continuous open tube or pipe. These connect with similar tubes in the young stem so that these tissues (xylem tissues) form a complete plumbing system for the upward movement of water through the plant.

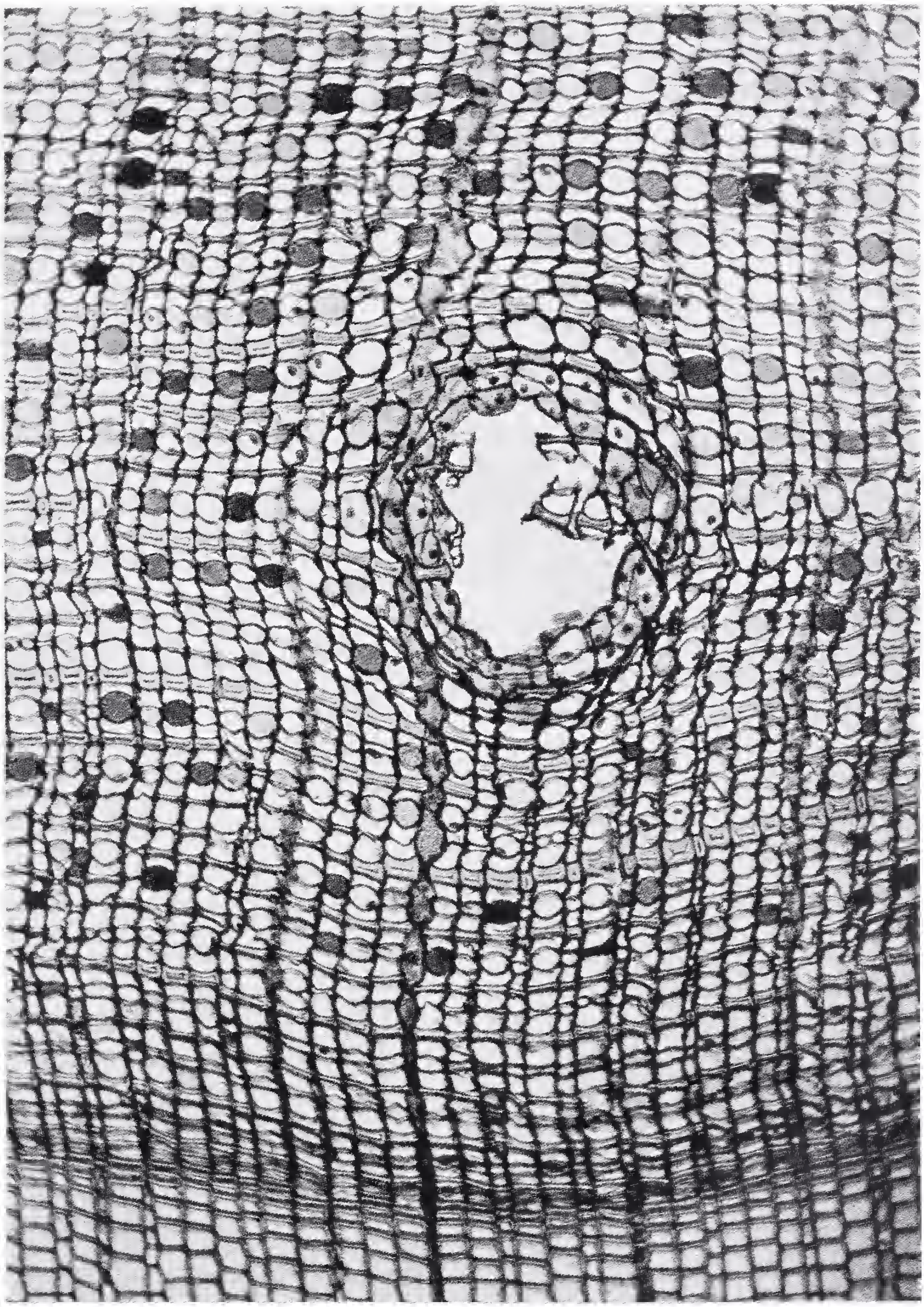
At the same time, other cells in the young leaf, closely associated with the developing xylem, are altered into different cell types (phloem cells), connect with phloem in the stem and are ready to function in the basal transport of sugar. Finally, cells in intimate contact with both xylem and phloem may form very heavy wall thickenings and serve to strengthen the vascular system of the leaf. All of these various cell types comprise the veins of the leaf.

Even before 17th-century botanists turned their hand lenses and crude microscopes on plant tissues, the term "veins" had been applied to the vascular bundles in the leaves by analogy with the veins that were seen on human hands. Since they knew that liquid flowed in their own veins, they assumed, quite logically and correctly as it turned out, that liquids were flowing through leaf veins.

The general public and the avant-garde of 19th-century plant physiologists didn't know how these liquids moved, but because leaves could "bleed" when their veins were cut, they made some shrewd guesses which, unfortunately, were almost all wrong. Although the precise physics of water and sugar movement into and out of leaves is still not completely understood, the idea that enthralled the 19th century—that there was some kind of a pump in plants comparable to the heart—was only laid in the dustbin of scientific speculation in the early decades of the 20th century.

Modern research has shown that water moves up from the root-soil interface into the stem and thence into the stems and leaves and eventually evaporates through the multitudinous pores (stomates) of the stem and leaf into the atmosphere. It is, in fact, the "suction" action of this evaporation that pulls the water up the plant. Measurements of this suction force show that it is more than enough to pull the water in the microscopic lumens of the xylem pipes to vertical distances far in excess of the height of the tallest trees.

We are considerably less confident in our understanding of the physical forces that move dissolved sugars in the phloem system down from the leaves, since the best current hypotheses are demonstrably inadequate. This doesn't give us peptic ulcers, but is a



Cross section of white cedar (*Thuja occidentalis*) ×110. The largest feature is the resin canal, the compressed area at the bottom is the outer part of a growth ring. Most of the tissue above this ring is phloem (downward conducting vessels). Where it is dense and cells are narrow is where the phloem meets the cambium (one cell wide) and the xylem (woody vessels conducting water and nutrients upward).

challenge which plant anatomists and physiologists have accepted; we get our kicks (and our salaries) by trying to puzzle such things out.

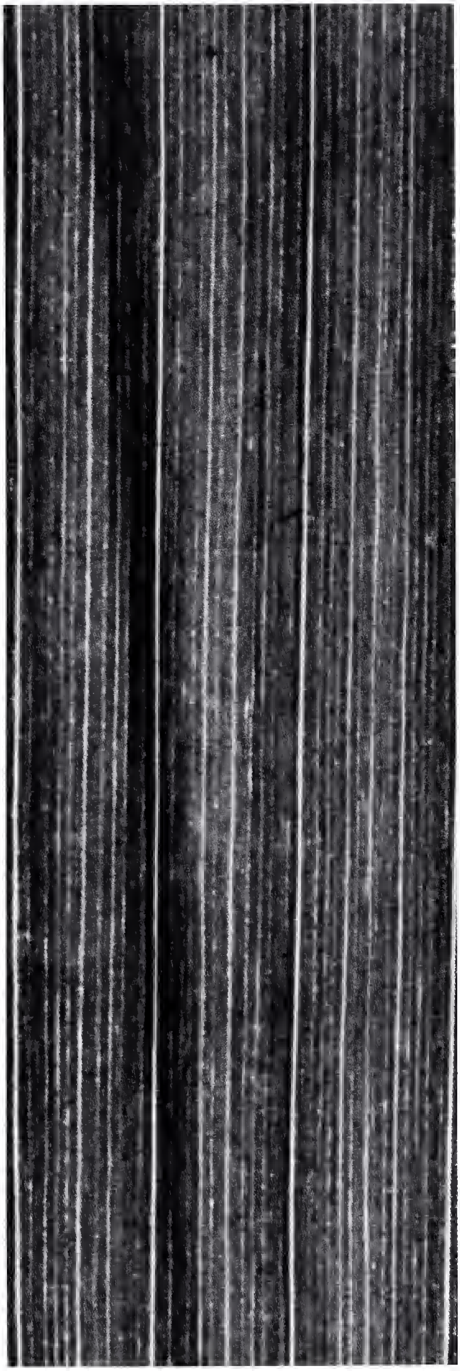
The Patterns in the Plumbing

Just by looking at leaves, we can get a good idea of how beautifully designed the vein system is. The vascular connections to the plant stem are most easily seen on twigs in winter after the leaf has fallen. The place where the leaf stalk joined the stem is seen as a scar, and at one or more places on the scar can be seen small dots, each one being the plugged end of a vascular bundle of xylem, phloem and supporting tissues, which had entered the leaf stalk. The fact that these vascular bundles traverse the leaf stalk can be easily observed. In the monstrously elongated leaf stalks of celery, the bundles are the small dots forming an arc on the convex side of the stalk.

At the junction of the leaf stalk and the flattened leaf blade, the vascular bundles become apparent as the leaf veins. The two general leaf venation patterns correlate with the two major groups of flowering plants—the monocots, in which the embryo of the seed has one cotyledon, or seed leaf, and the dicots, in which the embryo has two cotyledons. It has long been a botanical rule of thumb that most (but not all) of the monocots have their major veins running parallel to each other and that the parallel venation pattern replaced that of the dicots, which usually have a repeatedly branching network of veins.

The grasses and palms as well as the orchids and lilies are monocots and are parallel-veined. If you trace the veins, you will see that there is usually one or several veins of equal diameter extending the length of the leaf, with smaller veins branching off in regular order. The smaller veins also usually run parallel to each other, with very little secondary branching to the sides of the leaf. It's worth noting that not all monocots have parallel venation, but the rule of thumb is still useful.

Net venation patterns typical of dicots include two major sub-pattern types, the most common being the pinnate arrangement. In pinnate patterns, such as in elm and beech leaves, there is one main vein that divides the leaf into two halves, with



A monocotyledon (one leaf at a time from the seed, such as onion) has parallel veins, rather than networks of veins. Here is the parallel leaf pattern in a corn leaf.

secondary veins diverging from this midrib and tertiary veinlets dividing, sub-dividing and rejoining to give the leaf's netted appearance.

In dicots such as household ivy and maples the vein system is called palmate; there are several main veins, all originating from the leaf stalk-leaf blade junction to give a fanlike array. Each of the major veins shows the net branching and sub-branching design. In a third variation, much less common than the others, called dichotomous branching, the main vein divides into two veins, each of these again divides into two and so on.

Leafy Origin of Tendril and Flower

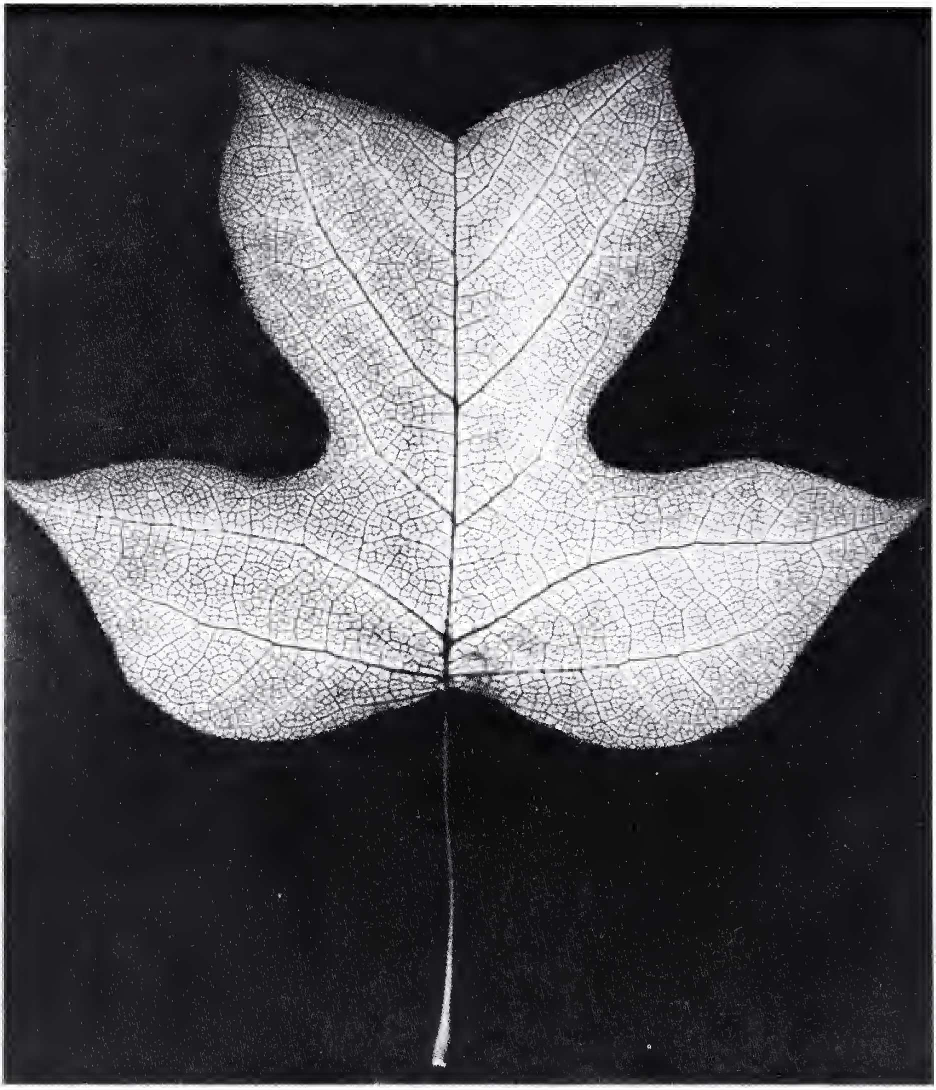
Venation is not restricted to leaves, but is also seen in plant parts that are derived from leaves, such as the tendrils of pea or bean plants, the organs by which the plant climbs up trellises or poles. One or two major veins take up most of the cross-sectional area of the tendril. The fact that tendrils are so difficult to pull away from the trellis at the end of the growing season is due to the presence in the vein of cells with thickened cell walls that confer a good deal of tensile strength.

Flower parts retain the vein patterns of the plant parts from which they develop. Each of the petals of a rose shows its leafy origin—as do the green sepals and, not surprisingly, the male and female reproductive structures. Indeed, the filaments of the anthers are almost entirely vein tissues—they contain xylem, phloem and the strengthening cell types found in tendrils and foliage leaves. In most fruits the vein system is less apparent, but you may be assured that it is present and active during the period in which the fruit is developing.

In order to understand fully the roles of the veins, we would have to study the microscopic structure of leaves, but we can get a pretty good idea of how intimate is the association between veins and the tissues they serve even without sophisticated gadgetry—just by examining a leaf skeleton.

If you pick up a leaf that has overwintered in a pond, you will see that the softer tissues have disappeared—they have been broken down by the bacteria and fungi, leaving intact just the tougher vein tissues. Not only are the net or parallel venation patterns

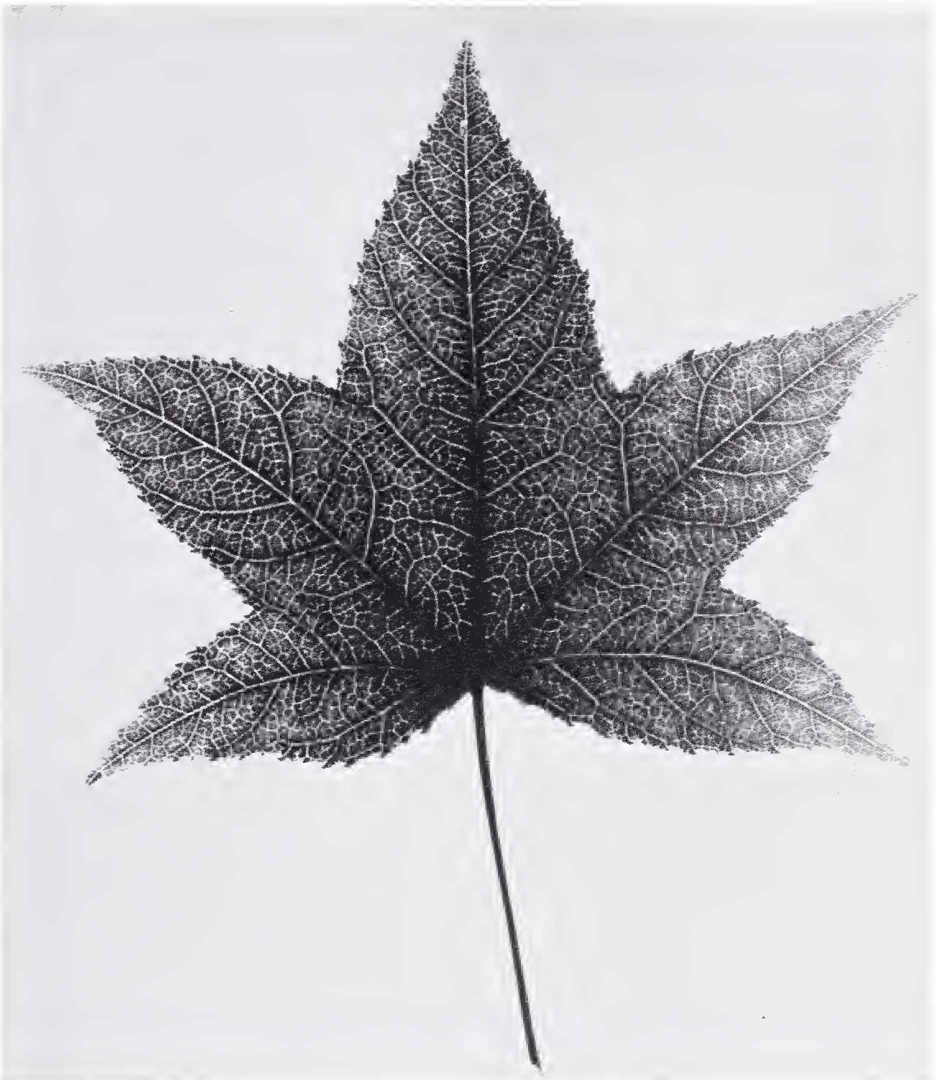
The wild-cucumber (*Echinocystis lobata*) is a climber that anchors itself with tendrils, specialized features derived from leaf tissue.



Pinnate venation, where a central vein divides a leaf in half, is illustrated here in a tulip tree (*Liriodendron tulipifera*) leaf.

beautifully apparent, but you can also see that the very fine veins are so ordered in space that each of the photosynthetic cells of the active leaf would have been only a fraction of a centimeter from a veinlet. The veins are so arranged that water coming into the leaf can be rapidly diffused to the cells that need it and also to the stomates where the evaporation takes place. Food formed in photosynthesis has an equally short path from the food-producing chloroplast factory to the pipes that move it to the consuming cells as far away as the nethermost root tip.

When confronted with any set of patterns in the structure and function of plants, botanists invariably try to see if the possession of a particular pattern has permitted the plant to be better adapted either to its present habitat or to conditions that might have existed during the evolution of the plant. In venation patterns, no correlations have been



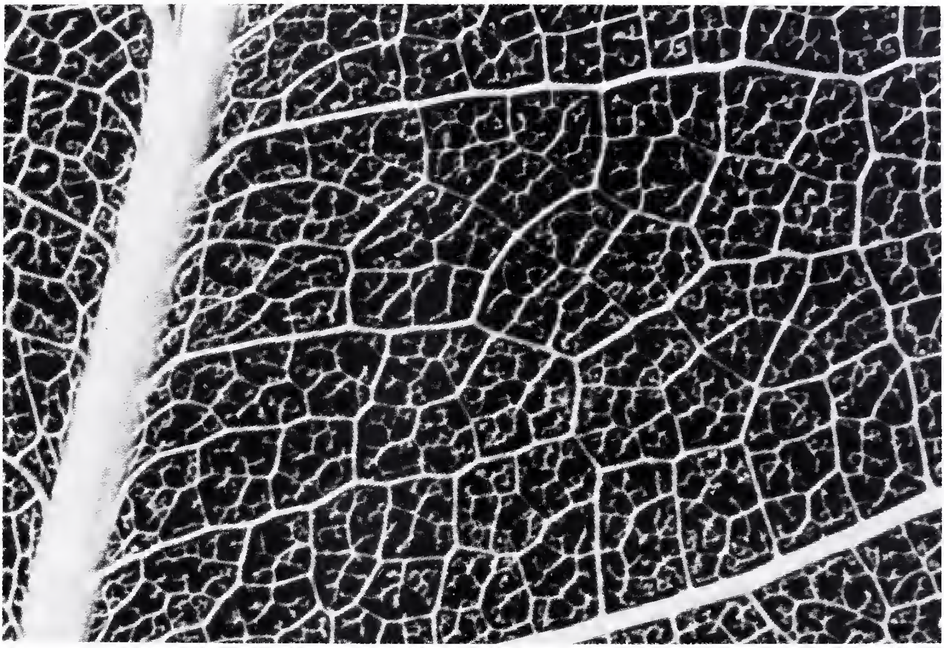
Palmate venation, here in sweetgum (*Liquidambar styraciflua*), has veins originating at the base of the leaf, then radiating like fingers.

proposed with which all botanists can agree.

Small, net-veined leaves with toothed margins—such as are found on alder shrubs—are common leaf types in the harsh environments of the cool-to-cold boreal forests of northern North America, while more open parallel or palmate patterns predominate in some tropical areas. In very rainy areas, such as the tropical rain forests of the Philippines or the Hawaiian Islands, many plants have leaves with attenuated ends—drip-tips from which water can flow.

Since particular leaf patterns are not always found in association with a particular habitat, and plants with one type appear to grow as well or as poorly as those with another, the significance of the patterning is obscure.

Some correlations between structure and habitat adaptations have provided significant breakthroughs in our knowledge. A case in point is the bundle sheath. A century



A magnolia-shaped leaf from South America, shown here in negative enlarged four times and with the soft tissue removed, shows how complex the division and redivision of the veins can be.

ago, German microscopists found that some plants possessed a ring of large cells surrounding each of the veins and that in these bundle sheath cells the chloroplasts were different from ordinary ones. Unable to ascribe any evolutionary or functional significance to these findings, the information languished in the scientific literature for close to 90 years. Finally a group of plant biochemists discovered that some plants could fix carbon dioxide into sugar more efficiently than others. It became apparent that this more efficient photosynthetic process—named the Hatch-Slack photosynthetic pathway after its discoverers—occurred only in those plants whose leaf veins were surrounded by bundle-sheath rings.

Such plants have a mechanism for collecting more carbon dioxide than do plants without the bundle sheaths, and can do so under conditions of high temperature such as in deserts or tropical mountainous habitats. As it happens, people have cultivated these efficient plants because they can grow rapidly and they produce considerable sugar. Our sugarcane, sorghum and maize are Hatch-Slack plants and, to our sorrow, so is that very efficient and tenacious pest, crabgrass.

Gardeners, only slightly more than other mortals, are enchanted with the intrinsic beauty of the patterning of veins. Obviously, the plant didn't develop its patterns for our personal enjoyment, but we select and breed plants that have vein patterns we find pleasing. In the prayer plant, *Maranta,* the episcias and caladiums, cells associated with the veins synthesize pigments that contrast with the green color of the rest of the leaf. We have bred caladiums with only the vein-associated tissues green and aphalandras with the veins white. We can purchase nasturtiums with yellow petals streaked with red along the veins and bearded iris with bold white veins contrasting with rich blue petals. The variation in vein appearance in peperomias and other plants due to puckering around the veins or the swelling of interveinal tissues is also an appreciated variation on a theme. These plants are selected, but far from isolated, examples of some of the most beautiful plumbing in the world.

PLANT NOMENCLATURE

A Capsular Consideration

Michael A. Dirr

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What is this thing called a species? What do the Latinized terms signify? How did the present system for naming plants evolve? Actually a historical sojourn would uncover several interesting facts concerning plant nomenclature. Before the Linnaean (binomial) system was accepted as a standard for naming plants, nomenclature was literally a disaster. Plants were named *descriptively.* Latinized adjectives were added until sufficient verbiage was present to allow differentiation among plants. These Latinized terms usually described morphological (physical) features of the plant. For example, the common carnation which is now *Dianthus caryophyllus* L. was, before 1753, "Dianthus floribus solitariis, squamis calycinis subovatis brevissimus, corollis crenatis."

Linnaeus

The question which arises is how was this chaos made orderly? It is credited to Carl von Linné, more commonly known by his pen name of Linnaeus. His book, *Species Plantarum* (1753), signaled the beginning of the binomial system of nomenclature. Essentially it means that plants acquire two Latinized names, one representing the *genus* and the other termed the *specific epithet,* which in combination with the generic name constitute the *species* by means of which all plants or animals are known by all people in all countries who speak or write of them with precision.

Those who work with and read about plants are continually exposed to the concepts of genus, species, variety, and cultivar. These terms appear in every nursery catalog, gardening article or publication concerning plants. However, what do they signify? Is there any practical significance to them and will understanding their meaning enhance one's appreciation for plants?

Genus

The genus is weakly defined as a more or less closely related and definable group of plants comprising one or more species. The genus is a category whose components (i.e. species) have more characters in common with each other than they do with components of other genera within the same family. Similarity of flowers and fruits is the most widely used feature although roots, stems, buds, and leaves are used. There may be a single species comprising a genus such as in the case of *Ginkgo* where the species *Ginkgo biloba* L. is the only member. At the other end of the spectrum the genus *Rosa* (rose) contains between 100 and 200 species. The generic name is written with a capital letter and italicized [*Quercus* (oak)]. The plural of genus is genera and not the often used genuses.

A.B. Morse Co.

The 'Peace' rose, possibly the best-known cultivar in the world.

Species

Possibly the most important unit of classification is the species; however, the term is more a concept than an absolute entity. L. H. Bailey defined a species as a kind of plant or animal distinct from other kinds in marked or essential features that has good characters of identification, and may be assumed to represent a continuing succession of individuals from generation to generation. He then went on to say that the term is incapable of exact definition for nature is not laid out in formal lines. Actually, the species term is a concept, the product of each individual's judgment. A species name is composed of the following components and written as follows in this case for sugar maple.

Acer	*saccharum*	Marsh.
genus (Maple)	specific epithet (Sugar)	The authority or individual who first and correctly names the tree, in this case, Humphrey Marshall.

Note that the species name is in italics and the specific epithet is lower case italic. The plural of species is species and the authority name (not italicized) does not have to be included in normal writing.

Varieties and Cultivars

The term variety as used in the botanical sense constitutes a group or class of plants subordinate to a species (subspecies) and is usually applied to individuals displaying rather marked differences in nature. The crux is that these differences are inheritable and should show in succeeding generations. The difference between the thornless common honey locust (*Gleditsia triacanthos* L. *inermis* Willd.), a true variety, and the species, common honey locust (*Gleditsia triacanthos*), is the absence of thorns on the former. Seed collected from the variety will yield predominantly thornless seedlings, although a small percentage of the population will exhibit the thorny character. Unfortunately, variety is often confused, and used interchangeably, with the term *cultivar* (a term coined by L. H. Bailey). The variety term is always written with the species, in lower case, and italicized or with the abbreviation "var." placed before the variety term and the italics omitted. The plural of variety is varieties. For example the pink flowering variety of the white flowering dogwood (*Cornus florida* L.) may be written as follows.

Cornus florida rubra
or
Cornus florida var. rubra

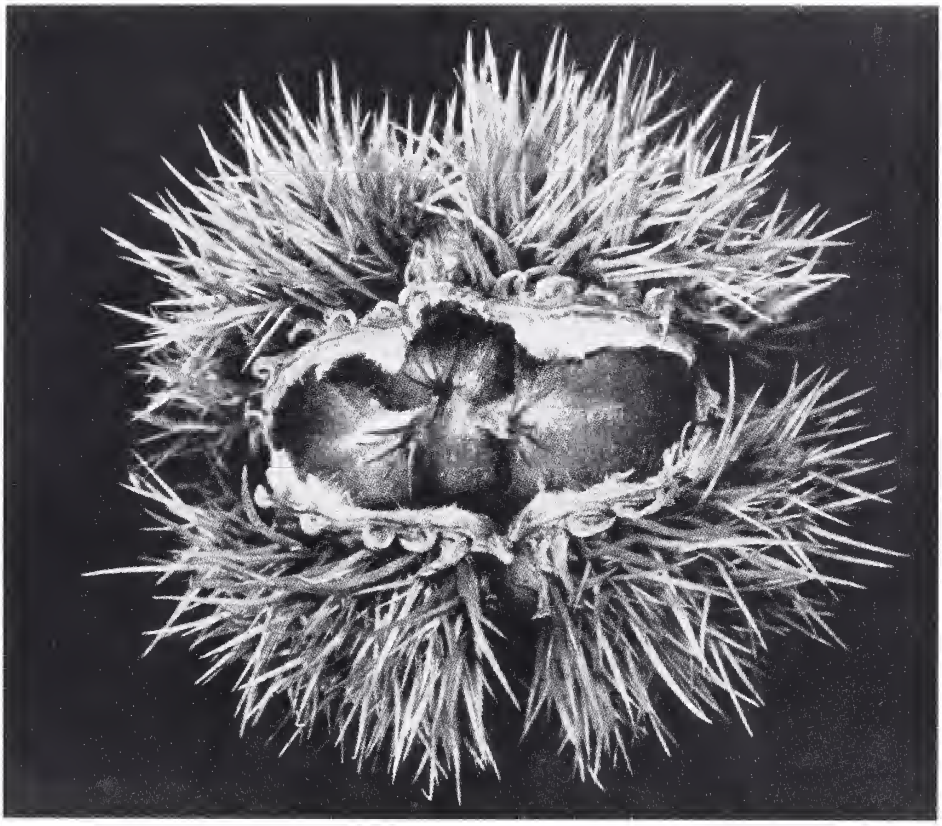
A relatively new term and one which has important implications in horticultural circles is that of cultivar. A cultivar is an assemblage of cultivated plants which is clearly distinguished by any characters (morphological, physiological, cytological or chemical) and which when reproduced asexually, or sometimes sexually, retains its distinguishing characteristics. The difference between Norway maple (*Acer platanoides* L.) and the cultivar Crimson King (Acer *platanoides* 'Crimson King') is the purplish-maroon foliage color of the cultivar. This cultivar cannot be reproduced from seed (hence does not fit the definition of variety) and must be reproduced vegetatively (grafted) to maintain the foliage characteristic. Essentially all other characters of identification between this species and the cultivar are similar.

Sexually reproduced cultivars include those plants (annuals such as petunias, marigolds and asters) which are propagated from seed derived from the repetitive crossing of two or more parental breeding stocks maintained either as lines or clones. A line consists of a group of plants that are largely homozygous (similar in genetic makeup). *Clone* is a group of plants which originated asexually from a single individual and, therefore, is genetically homogenous.

Cultivar names are written with single quotes and the first letter of each word comprising the term is capitalized or the insertion of cv. before the term and the deletion of the single quotes.

Example: *Acer platanoides* 'Crimson King'
or
Acer platanoides cv. Crimson King

It is possible to have a cultivar of a variety. *Cornus florida* var. rubra is the pink flowering form of the flowering dogwood. A cultivar of this variety is Cherokee Chief which possesses deeper red flowers. The term would read *Cornus florida* var. rubra 'Cherokee Chief'. ❧



W.M. Harlow/Dover

American chestnuts (*Castanea dentata*) in bur

SEEDS: A PICTORIAL SURVEY

Peter K. Nelson

A seed is a natural marvel of packaging: compact, complex and complete. Throughout most of their evolution plants reproduced by spores or by various vegetative methods and at various times different groups such as club mosses, horsetails or ferns dominated the earth's surface. When seeds, which basically are modified spore-bearing structures enclosed in special protective covers, appeared, the advantage they conferred gave seed-bearing plants such superiority over other plants that they quickly became the dominant vegetation. These seed plants, technically called Spermatophytes, have maintained their dominance to the present time.

The seed plants can themselves be separated into two kinds. In the first of these the seeds are borne either on the tips of small branches or on the surfaces of scalelike structures that are grouped into compact clusters we know as cones. *Ginkgo* is a good example of the first of these types; the familiar conifers such as pines, spruces and larches are examples of the second. Because the seeds of these plants are not completely enclosed in any structure, but are more or less exposed, the plants are called *Gymnosperms,* from Greek words meaning *naked* and *seed.* Later in the course of plant evolution the seeds became totally enclosed in structures that when mature are called *fruits.* Fruit-bearing plants are *Angiosperms,* again from Greek words meaning *vase* or *container* and *seed.*

Just as the development of seeds gave a great advantage to those plants that produced them, fruits have given the Angiosperms an advantage over the Gymnosperms and today the Angiosperms, or flowering plants, are by far the dominant vegetation of the earth. Since the Angiosperms are our most numerous and familiar plants we will give most of our attention to their seeds, though a few Gymnosperm seeds are also illustrated.

An Angiosperm seed, which develops from an ovule in the pistil of the flower, (see page 46 for floral structure) consists of four parts: a small stalk, the *funiculus,* which attaches the seed to the fruit wall; the *seed coat,* which may be hard or soft, thick or thin, rough or smooth; the *embryo* which is the young new plant; and the *endosperm,* a tissue unique to the Angiosperms in which food for the developing embryo is stored. (Gymnosperm seeds also have food-storing tissue, but it is totally different in origin and structure from the endosperm of the Angiosperms.)

The embryo, which is the most important part of the seed, usually consists of one or two modified leaves called *cotyledons,* a more-or-less well developed root called the *radicle,* and a small stem tip, the *epicotyl.* If the epicotyl has the beginnings of regular foliar leaves (minute and often much folded up), these are called the *plumule.*

Like the endosperm, the cotyledons usually serve as food storage organs. In some seeds all of the food from the endosperm is transferred to the cotyledons during seed development, and when the seed is ripe the endosperm has disappeared, absorbed by the embryo. In others, at the ripe stage the embryo is still small with barely-formed cotyledons and all the stored food is still in the endosperm. Between these two extremes every degree of development can be found.

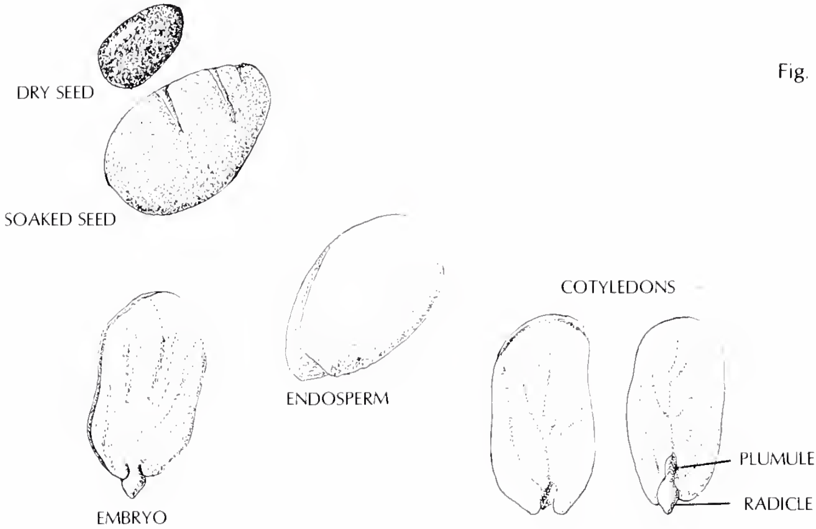
At seed germination the cotyledons of some seeds remain underground, functioning solely for food storage; in others the cotyledons emerge with the stem, but quickly shrivel and drop off; while in still others they emerge, expand, turn green and function for a longer or shorter time as the leaves they actually are.

During the development of some seeds, tissue grows out of the funiculus and more-or-less completely covers the seed. This extra tissue is called the *aril*—often incorrectly referred to by crossword puzzle authors as the seed coat. Some botanists consider the possession of an *aril* to be a primitive trait among Angiosperms.

Examination of a number of different seeds (and some fruits) will help to clarify the various structures and their variations. The reason for including fruits is that many of what are commonly thought of as seeds are actually whole fruits. As an example, a sunflower "seed" is a fruit, with one seed inside.

Honey locust (Fig. 1). The seeds of honey-locust (*Gleditsia triacanthos*), are good to begin with because they illustrate all of the principal parts very clearly and are of a convenient size to work with. The ripe seeds, about the size of a navy bean but somewhat flattened, have a very hard, thin seed coat and are borne in a podlike fruit called a *legume.* Typically a legume splits along two sides when ripe and dry and the plants having such fruits are also often referred to as "legumes." Peas, beans and sweet peas are well-known examples. The coat of the honey locust seed is not only hard but waterproof and in water the seeds will remain unchanged for days. However, if a small break is made in the coat before soaking, the seed will swell in one or two days to two-to-three times its original size. The seed coat will become soft and pliable and can be easily peeled away showing inside a grayish, translucent layer of endosperm inside of which is a bright yellow embryo shaped somewhat like a ping-pong paddle. The handle of the paddle is the radicle, the blade the two cotyledons. They are rather thin and can be easily separated to reveal the plumule consisting of two very minute, partly developed leaves. Concealed between them is the tip of the epicotyl which can only be easily seen with the help of a magnifier.

Fig. 1



HONEY LOCUST

Drawings by Peter K. Nelson

Peanut (Fig. 2). Like the honey locust, the peanut is a legume and the whole fruit is illustrated. Peanuts are unique among legumes, and indeed among flowering plants as a whole, in that the flowers are borne near the base of the plant and as the fruits begin to form, their stalks elongate and bend downward, forcing the young fruits under the soil where they ripen. This peculiar behavior is reflected in the second part of the scientific name of peanut, *Arachis hypogaea: hypo-* meaning below or under, and *-gaea* meaning earth. The seeds have a thin, brown, papery seed coat and the cotyledons are the kind, mentioned in the introduction, that absorb all the food from the endosperm. There is no sign of this tissue in the ripe peanut seed, and the

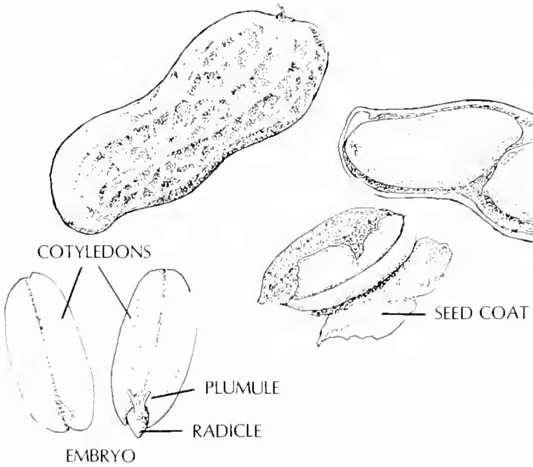
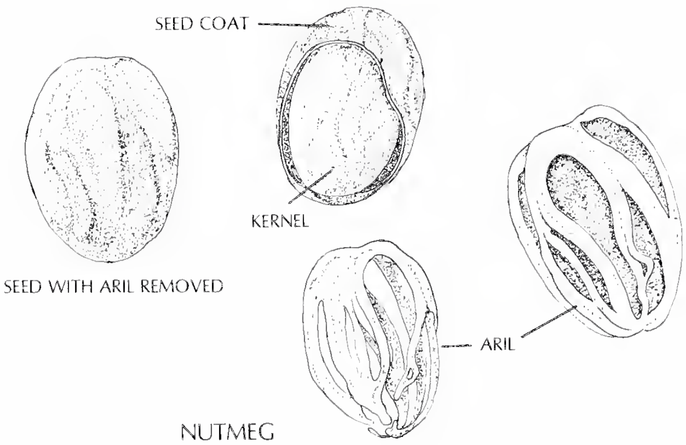


Fig. 2

PEANUT

Fig. 3

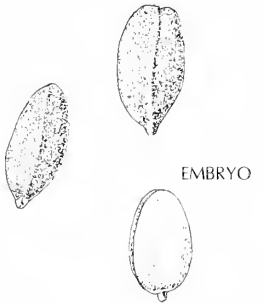


NUTMEG

cotyledons make up practically the whole thing. They can be separated to reveal the radicle and the plumule.

Nutmeg (Fig. 3). This common kitchen spice comes from a tropical tree which bears fruits somewhat resembling small peaches. When ripe this fruit splits open revealing the single large seed within, the kernel of which constitutes the spice. Nutmeg represents the kind of seed possessing an aril, an unusually interesting one. It is in the form of a kind of network and when fresh is a beautiful scarlet color, contrasting with the dark brown seed coat beneath. In addition this aril is itself aromatic and flavorful and constitutes the spice *mace*. Unfortunately when dry it loses its bright color. The seed coat is of moderate thickness and is hard but brittle, the compact embryo inside is the nutmeg spice.

Fig. 4



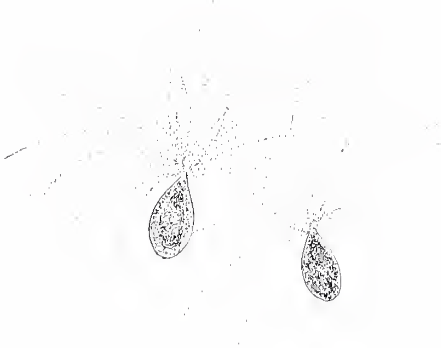
JEWELWEED SEED

Jewelweed (Fig. 4). The seeds of jewelweed, also called touch-me-not, are included here chiefly because they are favorites of mine. They are the only seeds I know that have colored embryos—their cotyledons an exquisite turquoise blue. The common name of jewelweed is supposedly owing to the fact that drops of dew glisten on the waxy leaves like gems, but I wonder whether some sharp-eyed early botanist may not have seen these embryos and named the plant for their jewellike appearance. The other common name, touch-me-not, derives from the small elongated fruits which when ripe explode at the slightest touch, scattering the seeds far and wide.

Milkweed (Fig. 5). Milkweeds (*Asclepias* spp.), employ different means for dispersing their seeds. The seed coats produce long, exceedingly light hairs which expand into a buoyant "parachute" when the pod (fruit) in which they are borne splits and exposes them to the air. They are caught by the wind and may be carried great distances from the parent plant.

Sow thistle (Fig. 6). A means of dispersal similar to that employed by milkweed is made use of by many plants such as dandelions, thistles and sow thistles (*Sonchus* spp.), illustrated here. But in these cases there is an important difference: the parachute is an outgrowth of the fruit and the whole thing is carried away by the wind.

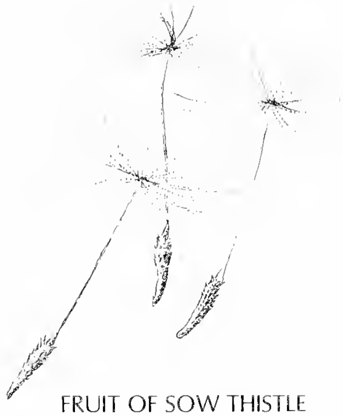
Fig. 5



MILKWEED SEEDS

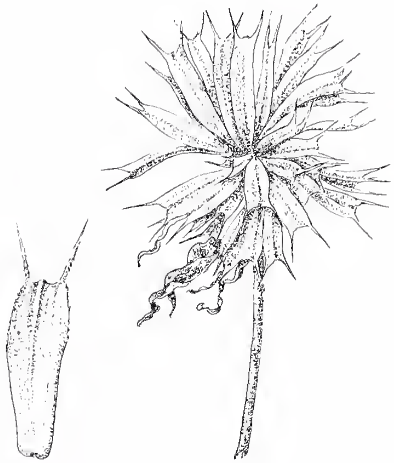
Beggar's-ticks (Fig. 7). Beggar's-ticks or stick-tights (*Bidens* spp.) along with many other plants make use of animals, including humans, to disperse their seeds or fruits. Most of the cases that come to mind are whole fruits and this is true of beggar's-ticks. The fruits in these plants are produced in clusters and each has at its outer end two sharp, barbed prongs which readily catch in fur or clothing and may be carried a long distance before dropping or being picked off. The burs of burdock employ small hooks rather than barbed prongs; and the leguminous tick-trefoils have flat fruits that break into segments and are covered with almost microscopic hooks. These almost have to be scraped away from any clothing they come into contact with. All are effective means of dispersing the seeds far from the parent plants.

Fig. 6



FRUIT OF SOW THISTLE

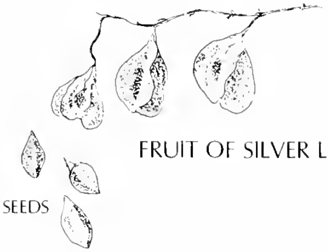
Fig. 7



PRONGED FRUIT OF BEGGAR'S TICK

Silver lace-vine (Fig. 8). This popular vine, *Polygonum aubertii,* has fruits and seeds typical of its family, the Buckwheat Family. The fruits often are winged, and

Fig. 8



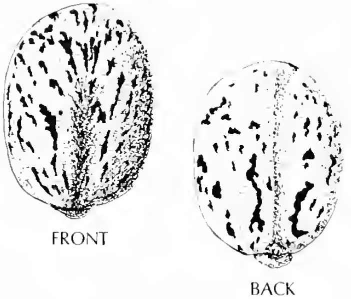
FRUIT OF SILVER LACE VINE

the seeds are triangular, often glistening black.

Rosary-pea and *Erythrina* (Fig. 9). These two leguminous plants, *Abrus precatorius* and *Erythrina* spp., both have many common names. The interest to us here is the beautiful coloring of their very hard-coated seeds. The ones shown have brilliant scarlet seed coats with patches of jet black. The rosary-pea seeds are of interest for another reason: they contain one of the deadliest plant poisons known. They are often used for beads and ornaments, but great care should be used to keep them away from children.

Castor bean (Fig. 10). This tropical plant is often grown in northern gardens for the exotic effect of its large palmate leaves. The seeds are valuable as the source of castor oil, but like those of rosary-pea contain a deadly poison which fortunately is water-soluble and therefore is not found in the oil. The large seeds are borne in spiny pods and have seed coats fancifully marked with irregular brown markings.

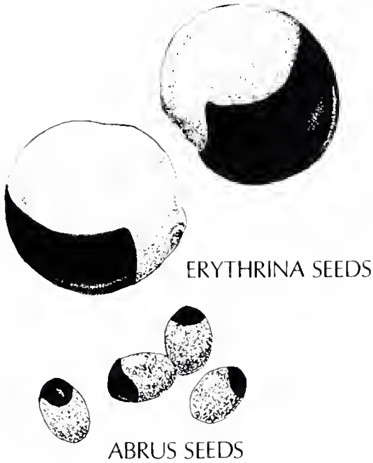
Fig. 10



CASTOR BEAN

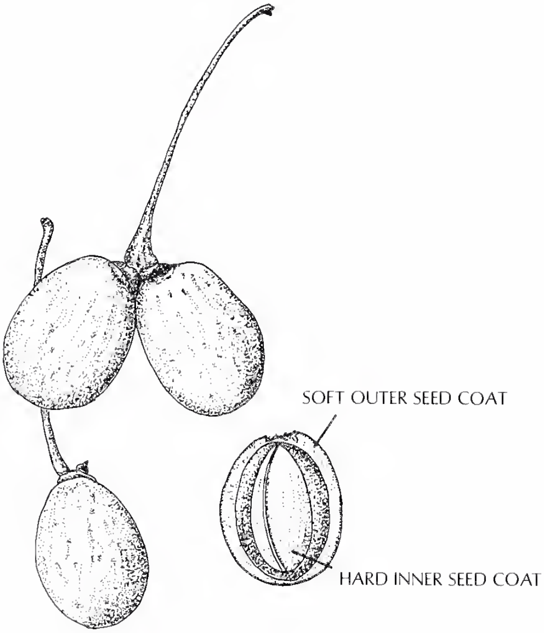
Ginkgo (Fig. 11). *Ginkgo biloba* is a fascinating gymnosperm often referred to as a living fossil. It was, in fact, known to western plantsmen only as a fossil for some time before living specimens were found growing in temple gardens of China. Its fan-shaped leaves give it the common name of maidenhair tree as in shape they resemble the leaflets of the maidenhair fern. The seeds are borne, usually in pairs, on short branches. They have a double seed coat, the outer layer being soft and fleshy, the inner hard and woody. They bear a striking resemblance to small yellow plums, and are often mistaken for fruits, the hard inner part seeming much like the pit or stone of a stone fruit. Unfortunately the outer coat contains a large amount of butyric acid, and when they fall to the ground and begin to decay, a most unpleasant odor results. The trees are dioecious (Greek for *two houses*), the sexes being on separate trees and, of course, male trees produce no seeds, so are much more desirable for plantings than the female as they do not produce the objectionable smell in autumn.

Fig. 9



Yew (Fig. 12). Yews (*Taxus* spp.), are actually conifers, but they do not produce cones. Rather, the seeds are borne on the branches and look like some kind of berry. They are nearly completely covered by an

Fig. 11

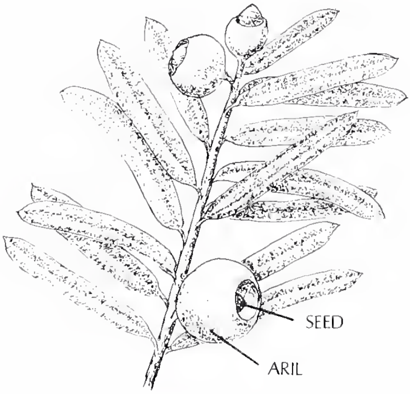


GINKGO SEEDS

aril which is soft and juicy and red in color. Interestingly, this aril is harmless, but all the rest of the yew plant—leaves, stems and seeds—is poisonous.

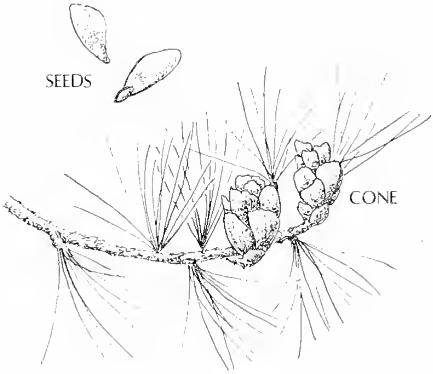
Larch (Fig. 13). Larch (*Larix laricina*), produces small but typical cones. Its seeds, like those of many other conifers, are small and bear thin papery wings that aid in their dispersal. Some conifers, notably the stone pines, produce rather large, wingless seeds the kernels of which are edible. Most people

Fig. 12



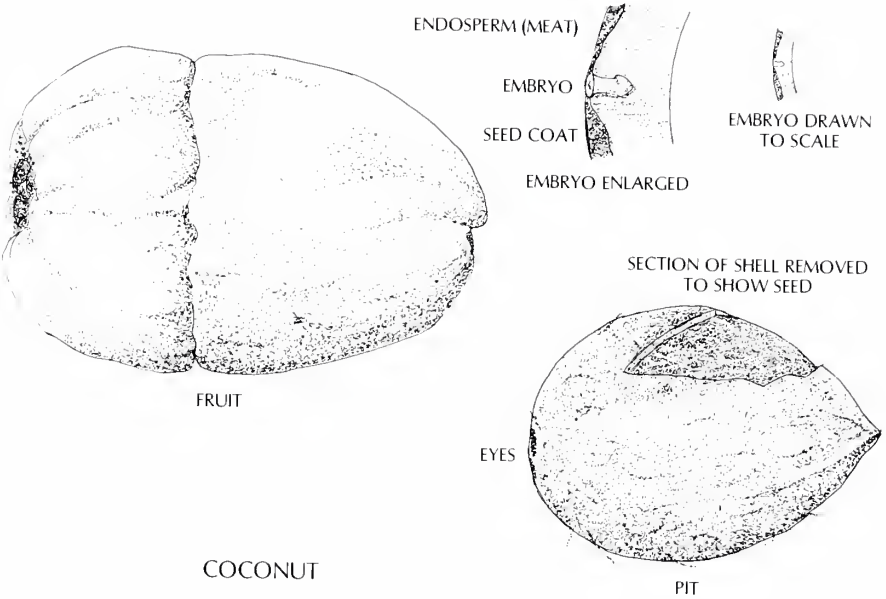
YEW

Fig. 13



LARCH

Fig. 14



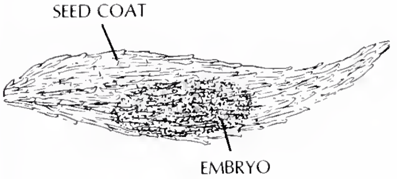
COCONUT

are familiar with the Italian pignolis or the piñon nuts of the American Southwest.

Coconut (Fig. 14). Seeds have a surprisingly large range of sizes, from the largest seeds, coconut, to those almost too small to be seen with the naked eye, such as orchids, Indian pipe, and a few others. Strictly speaking common coconuts have the second largest seeds, the so-called double coconut or coco-de-mer (*Lodoicea seychellarum*), being over twice as large. However this seed is not apt to be seen by many gardeners. The coconut with its husk is the fruit of the tree, the seed itself is only that part inside the shell. Many people have the impression that the shell is the seed coat, but it is not; the thin brown skin on the meat is the seed coat. The shell is part of the fruit, and corresponds exactly to the pit or stone of a plum, peach or other stone fruit. The coconut is one of those seeds in which the endosperm constitutes most of the seed and the embryo is tiny and poorly developed. Everyone is familiar with the coconut endosperm but many people may not realize that not only is the meat endosperm, but so too is the milk. In the early stages of development all of the endosperm is liquid, but as the seed ripens much of it forms solid tissue around the outer part of the seed. This same situation is found in a number of kinds of seeds, one familiar example being corn. The so-called milk in a ripe but not dry corn kernel is liquid endosperm. The coconut embryo is a small, peg-shaped structure embedded in the endosperm at a point just under one of the three "eyes" of the shell. This eye is softer than the others, so in opening the nut this is the one usually drilled through to drain out the milk, and the embryo is destroyed.

Orchids (Fig. 15). Orchid seeds are among the smallest and most simply structured of all seeds. They have no endosperm when ripe, the seed coat is only one layer of cells thick, and the embryo is only a rounded mass of a few hundred cells. Because there is no supply of stored food, in nature the

Fig. 15

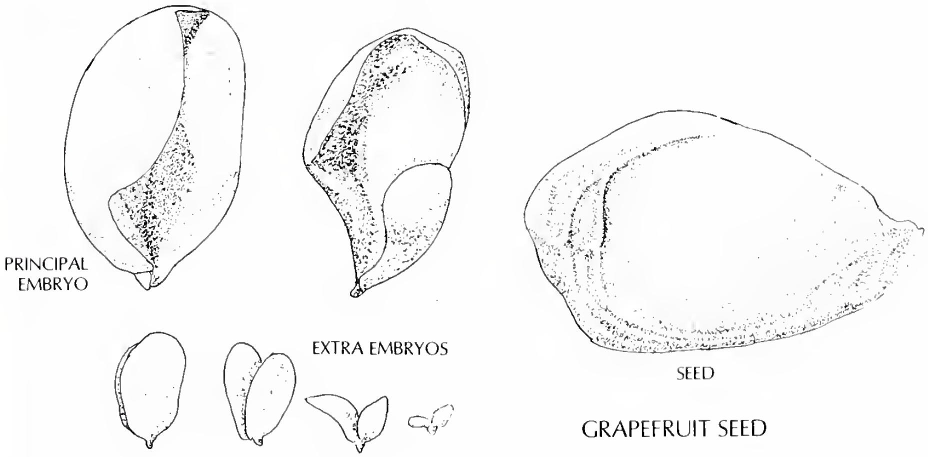


ORCHID SEED

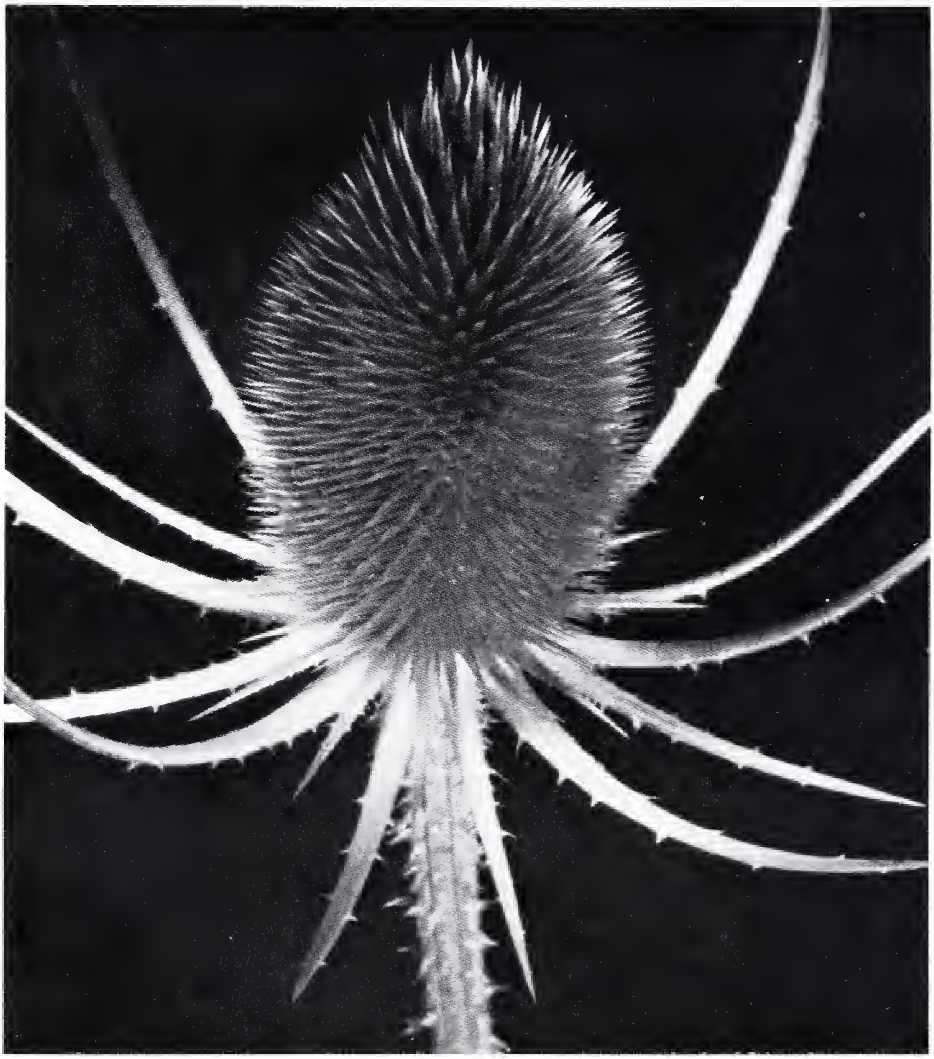
seed cannot germinate unless it becomes associated with a species-specific fungus with which it can live symbiotically and which will supply the embryo with materials needed for growth. In cultivation, the seeds are germinated on special media which contain all the necessary food materials. Since bacteria, molds and other organisms thrive on these materials, the orchid seeds must be grown under sterile conditions so they are not overwhelmed by competitors until they are large enough to get along on their own. It is interesting that the Indian pipe, *Monotropa uniflora,* which is in the Wintergreen Family, is in no way related to any orchids yet has seeds that are nearly indistinguishable from those of orchids.

Grapefruit (Fig. 16). Grapefruit (*Citrus paradisi*), as well as many other citrus fruits, notably tangerine, have seeds showing an unusual character; they have more than one embryo. Often when such a seed is planted, two or more seedlings come up. In citrus seeds, one of the embryos, usually the largest, may be a normal one, resulting from a fertilized egg cell. The others are formed from cells of an inner layer of the ovule wall and since they have not been fertilized by the male parent, the resulting seedlings from these embryos show only maternal characters. In the seed illustrated there were six embryos. Because of overcrowding they are often distorted, as are the larger ones here shown, and there is great variation in size. The smaller ones seldom, if ever, succeed in becoming seedlings. It is easy to see that this could greatly confuse the genetics of such plants. It is said that Gregor Mendel, after formulating his famous laws of inheritance as a result of working with peas, later worked with species of hawkweed. It happens that these plants often produce embryos without fertilization and Mendel ended in confusion, actually doubting his earlier work. Sometimes extra embryos are found in the acorns of oaks, but these are usually formed by splitting of the fertilized egg in early development, so the seedlings are like identical twins in humans. ❧

Fig. 16



GRAPEFRUIT SEED



W.M. Harlow/Dover

Wild teasel (*Dipsacus sylvestris*)

THE ARMORY—HOW PLANTS PROTECT THEMSELVES

Doris M. Stone

A plant is a singularly defenseless thing, or so it would seem at first glimpse. Yet it has many enemies—grazing animals that can eliminate it entirely, aggressive roots of neighboring plants that may restrict its own root growth and organisms of disease that may parasitize its tissues, threatening its vital functions.

Plants have developed a whole range of defense mechanisms directed against the diverse enemies lurking in the environment. They include: deterrents to feeding—spines, stinging hairs and skin irritants which discourage touch and poisons and unpalatable substances which halt feeding; protective growth habits; antitoxinlike substances which kill off the organisms of disease; chemicals emitted into the environment which keep other plants at a distance; partnerships with ferocious ants which drive away competitors and predators; camouflage.

Deterrents to Feeding

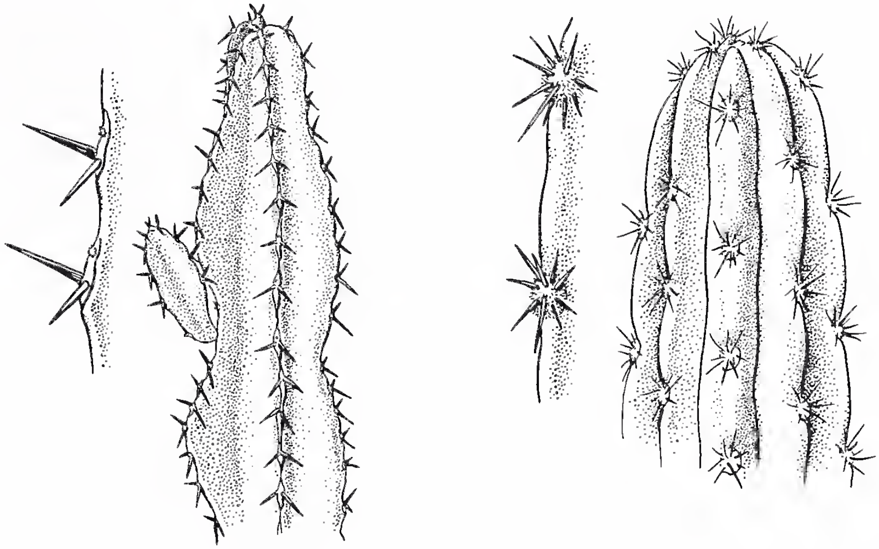
Because plants are the only organisms that can make food, they are the major source of nourishment for animals. Plants must, therefore, be able to sustain a certain degree of predation by animals. But predation has to be controlled, if plants are to survive.

Deterrents may be physical. Cacti (Fig. 1), some acacias and thistles have spines; roses possess thorns; comfrey and viper's bugloss bear soft, but irritating, bristles; aloes, yucca and the century plant have leaves that end in sharp spines. All of these weapons restrain, with few exceptions, browsing animals. Land iguanas, for instance, can eat cacti with impunity—in fact a prickly pear is the natural food of Galapagos iguanas.

More effective perhaps are chemical deterrents. Among these are corrosive substances such as those produced by stinging nettles, poison ivy and poison sumac, which irritate and blister the animal's mouth and skin. Most chemical deterrents, however, reside within the plant's tissues; some have unpleasant flavors, some are poisonous and some upset animal reproduction. They will be considered in turn.

For most animals sweetness is the most attractive taste. Bitter, acrid, pungent or astringent flavors are, in general, repellent. Since most poisons have an unpleasant taste, for instance, that of bitter almonds (prussic acid), poisonous plants tend to be avoided.

Most plant poisons are directed towards insects. During the evolution of plants insects posed the greatest threat. Only relatively recently has the human population increased sufficiently to endanger plant life. Insects, however, have always been a seri-



Euphorbia
(Old World)

Cactus
(New World)

Figure 1. Spiny Plants

Drawings by Bobbi Angell

ous menace because of their voracious appetites, explosive numbers and infinite adaptability.

Because of this orientation towards insects we are not aware of the widespread occurrence of plant poisons. Thus the naturally-occurring insecticides rotenone (from several rain forest trees) and pyrethrum (from chrysanthemums) come from plants harmless to us. Broccoli, cabbage, turnip, mustard and watercress, all members of the cabbage family, are poisonous to the majority of insects. The poison is mustard oil, released by chewing. Only caterpillars of the cabbage-white butterfly and the cabbage aphid have adapted to this particular toxin. For them it has become a feeding attractant.

For every plant poison there is at least one insect that has adapted to it. The cardiac glycosides, contained in milkweeds, toxic to both mammals and insects, are not only eaten by the monarch butterfly caterpillars, but are stored in their tissues and in the adult stage used as a defense against would-be predators. Fig. 2 shows a blue jay regurgitating a monarch because of its acrid taste.

The fact that the monarch and the cabbage-white butterflies have managed to penetrate the plant's defenses does not appreciably reduce the plant's survival rate. Protection from insects in general has been achieved and, in the case of milkweeds, from cattle also.

As feeding deterrents, substances which though unpalatable are not poisonous can be just as effective. Tannins, the astringent noticeable in strong tea, become plentiful in oak leaves only in late spring and summer. Caterpillars, which happily fed on oak leaves in early spring, now stop feeding. Presumably the development of these tannins protects the trees from complete defoliation. Members of the squash family contain bitter cucurbitacins which effectively deter most predators. (The bitter flavor of overripe cucumbers is due to a cucurbitacin.)

Certain plants contain animal hormones (or substances having similar effects) which upset animal development and reproduction. Ferns and gymnosperms, but not angiosperms, contain insect hormones that can cause sterility or even death to insect feeders. Angiosperms often contain estrogens, which upset the female cycles of mammals, causing abortion in cattle, ewes and even women. The most notorious is a clover species, *Trifolium subterraneum,* which is responsible for great losses among sheep in Australia.

Whether a reduction in grazing is the biological function of these hormones (or hormone mimics) is not certain. But it is perhaps significant that ferns and gymnosperms, as compared with angiosperms, are relatively free of insect pests.

Protective Growth Habits

Grasses are able to sustain heavy grazing (and mowing) and yet appear not to suffer from this chronic loss of photosynthetic tissue. The secret lies in the fact that their stems (rhizomes) are buried in the ground, as are the growing points of the leaves. Grazing animals can reach neither the stems nor the leaf growing points, making possible the continuous regeneration of new leaves and new leaf bases. Goats, however, can reach these vital areas, with the result that this animal has turned grassland into desert in many parts of the world.

Defense Against Disease Organisms

Certain bacteria and viruses and especially fungi invade plant tissues, living there as parasites and obtaining all food and nourishment from their hosts. Disease results when the growth and pathotoxins of the parasite interfere with metabolism to the extent that the plant ceases to function properly (Fig. 3). Death is the usual outcome. Most of us have seen this malfunctioning in elm trees afflicted with Dutch elm disease, a fungal infection that is invariably fatal.

Plants produce various kinds of toxins which combat invading microbes, the most interesting of which were discovered only recently. These are the *phytoalexins,* comparable to the antitoxins of animals. Plants resistant to a disease manufacture phytoalexins promptly, i.e., within 48–72 hours of the initial infection and in sufficient quantities to kill the invading organisms. Susceptible plants, though they may produce phytoalexins, produce them too slowly and in too small quantities to stem the infection.

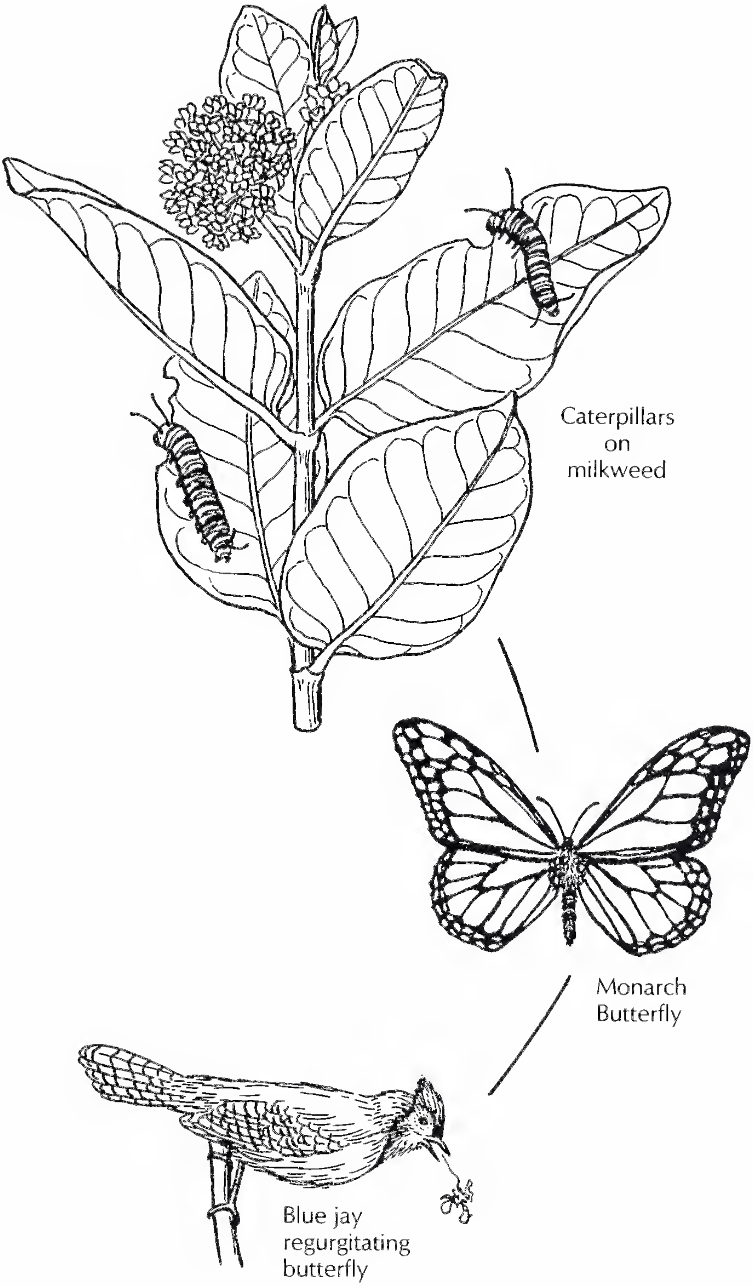
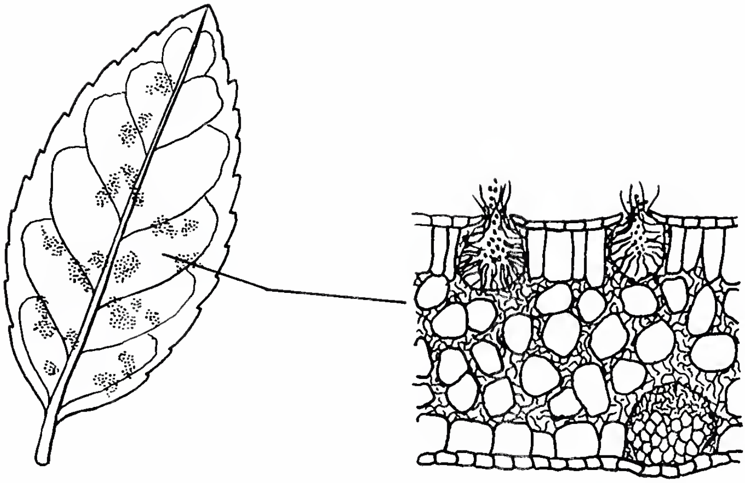


Figure 2. Exploitation of milkweed (*Asclepias* sp.) by monarch butterfly



Infected leaf
(rust fungus)

X-section showing penetrating
hyphae and circular
reproductive structures

Figure 3. The successful invasion of a leaf by fungal spores.

Resistance and susceptibility are inherited. A resistant plant inherits an acute sensitivity to the presence of microorganisms so that defenses are mobilized promptly.

Chemical Defenses Against Other Angiosperms

Allelopathy is the harmful effect of one higher plant upon another caused by the emission of chemicals into the environment. A well-known case of allelopathy is that of the black walnut tree. Its roots send out an innocuous substance into the soil which turns into a toxin called juglone. Juglone inhibits the growth of many plants, tomato and alfalfa being particularly susceptible (Fig. 4).

Shrubs in the Mojave Desert and chaparral regions of California are often surrounded by bare patches. Investigation showed that the decaying leaves of the desert shrub *Encelia farinosa* release a toxin into the soil which inhibits the germination of nearby seeds. Sagebrush and *Artemisia californica* of the chaparral give off gaseous toxins. Both above and below ground these shrubs are surrounded by a toxic zone, effectively preventing plant growth in the surrounding areas. Fire eradicates the toxins and five to seven years may elapse before they once again build up to allelopathic concentrations.

Partnerships with Ants

Certain tropical trees provide shelter and food for armies of fierce ants which in return attack foraging animals and even plants, such as the growing tips of vines that come too close. Using Central American *Acacia* trees that normally harbor ants, an interesting experiment was done. All the ants in the immediate area were removed. Without the ants the trees survived only a few months. Local species of *Acacia* that do not enter into ant partnerships contain toxic glycosides. It seems that in order to survive in that area *Acacia* species must have some form of defense mechanism.

In Africa tribes living in the natural habitats of the small tree *Barteria fistulosa* use it to mete out punishment to unfaithful wives. The unfortunate women are tied to the

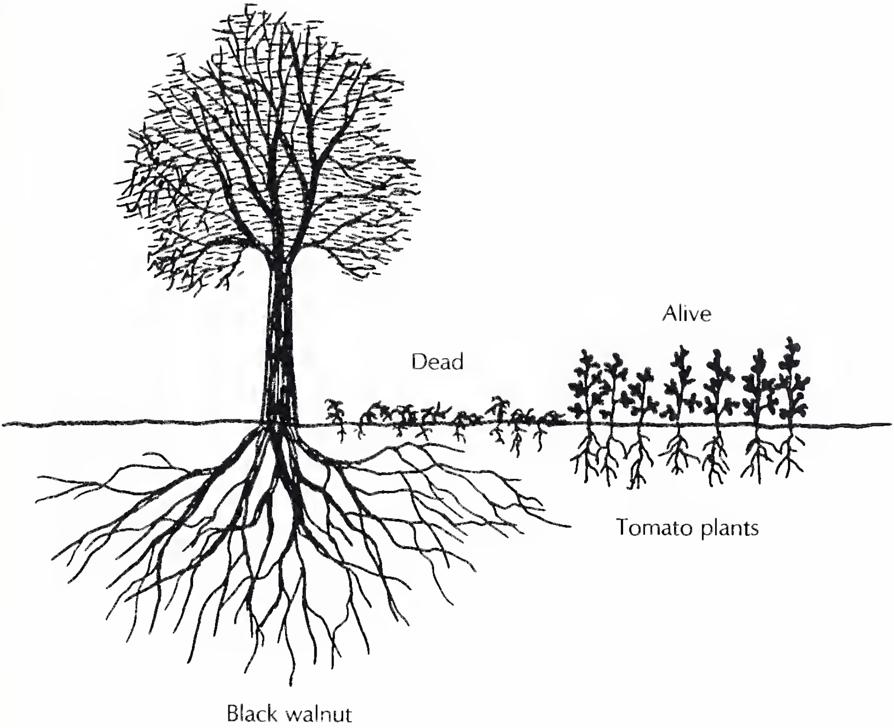


Figure 4. Allelopathy

Barteria trees. This species also has a symbiotic relationship with aggressive stinging ants.

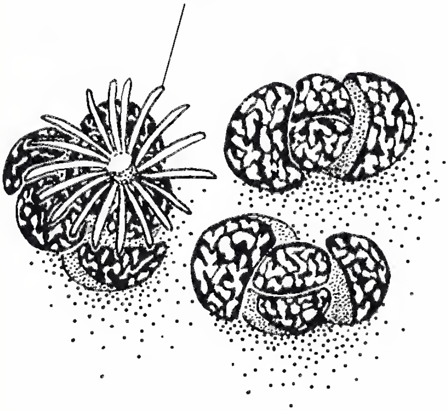


Figure 5. Living Stones: *Lithops* sp.

Camouflage

Camouflage is a form of defense commonly used by animals but rarely by plants. The exception is one specialized group of succulents native to the southwestern desert of Africa which looks like small rocks or pebbles (Fig. 5). A brownish pigment, which effectively masks the chlorophyll, adds to the disguise. They are called living stones, the majority belonging to the genus *Lithops* (from the Greek *Lithos,* stone). Two hemispherical water-storing leaves pressed closely together make up the entire plant. Only when it flowers does it give away its identity as an angiosperm.

Clearly, plants are anything but the passive defenseless things that they seem. Yet, because their biological role is to sustain all animal life on earth, they must be able to survive a certain degree of browsing and grazing. Their growth patterns, so different from those of animals, make this possible. ❧

AUTUMN COLOR

Stephen K-M. Tim

The spectacle of vivid color would seem appropriate garb for celebrating the advent of a season. In fact, the opposite is true; it is a sign of the winding-down of the plant's vital processes in preparation for the long winter rest.

Northeastern North America and eastern Asia are the two prime areas where autumn is synonymous with splendid color. The concentration of broad-leaved, deciduous trees and shrubs in combination with bright, mild days and cool nights of autumn are the key factors responsible for this phenomenon.

Colors exhibited are genetically determined. The birch is always yellow, the flowering dogwood mostly red to scarlet. In between colors, including the orange-reds and salmons, are characteristic of the sumacs, sugar maple, and even the infamous poison ivy.

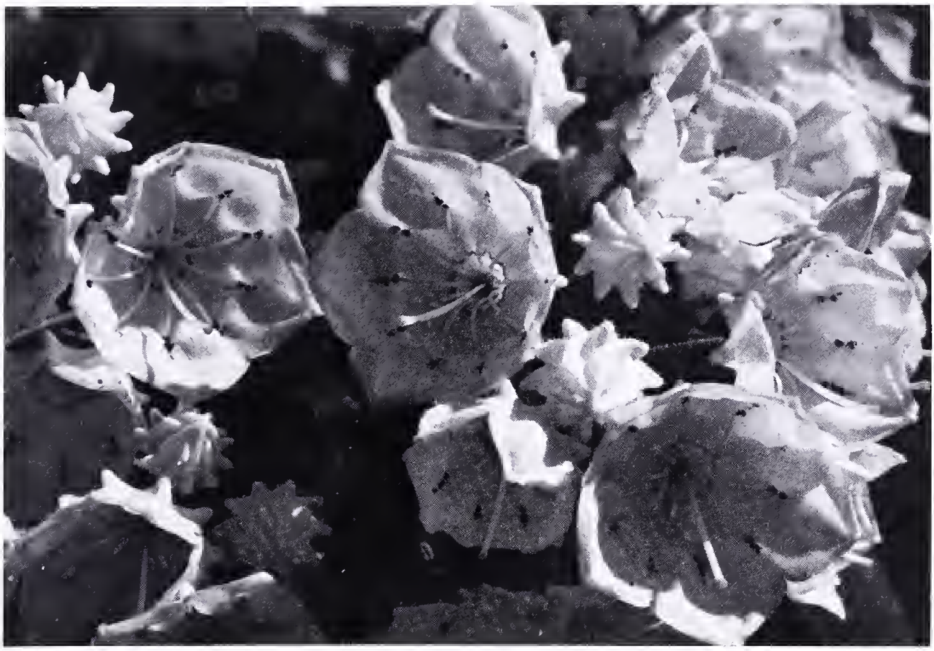
As the days of autumn shorten and temperatures drop, a number of changes take place in the leaves. A layer of actively dividing cells gradually forms across the leaf stalks or petioles. This is the process of abscission which restricts the flow of fluids in and out of the leaf and eventually results in the leaf dropping. The exchange of materials through the petiole greatly influences the synthesis of chlorophyll, the green pigment vital to photosynthesis. Chlorophyll must be continually replaced because it is broken down every few days. When the raw materials for its synthesis, particularly water and minerals, are prevented from flowing freely into the leaf, the rate of destruction of chlorophyll exceeds that of regeneration. Other hues, normally masked by this pigment, then come into prominence. These are primarily the yellow to orange pigments called carotenoids, so named because they provide the color in carrots. As opposed to chlorophyll, carotenoids are not dependent on light for their formation and are always present in the living leaf as well as in certain flowers, such as the daffodil.

Where leaves show red or scarlet, this is due to physiological changes in the leaf occurring in conjunction with suitable weather conditions. When autumn days are sunny and mild, sugars formed by photosynthesis accumulate in the leaf cells. For reasons which are not well understood, these sugars are transformed into anthocyanin, a pigment present in red, blue and violet petals, as well as beetroot and rhubarb leaf stalks. With cool nights, the translocation of these sugars from the leaf slows down and is further impeded by the developing abscission layer. Hence, sugars tend to be trapped in the leaf where they are converted to anthocyanin.

The blending of anthocyanin with carotenoids is hardly better rendered than in the sugar maple where each leaf is a palette of rosy reds, oranges and translucent yellows. Anthocyanin may even mask the carotenoids completely. On those bonus days of Indian summer when especially bright, warm days contrast with sharply cool, frost-free nights, the landscape is set afire with an intense grandeur, where red maple vies with the tupelo for the distinction of sporting the most vibrant red.

Many oaks contribute muted browns to the autumn scene. These result from the breakdown products of chlorophyll and the accumulation of tannins in the cells. But, combining these with a generous touch of anthocyanin and the lively wine-red of the white oak can result in a most surprising spectacle.

Autumn coloration—a phenomenon indeed!



M. Joyner

Spring-loaded anthers of mountain-laurel flowers

Why a Daisy Isn't a Lily . . .

THE SHAPES OF FLOWERS: CLUES TO POLLINATION

Pamela G. Hine

Lean back, close your eyes, and in your mind create a lush, primeval landscape. Fill it with tree ferns, cycads, horsetails and mosses, but be careful—no flowers! One hundred fifteen million years ago, just yesterday in the history of the world, you could not have dressed your garden with a single flower, not even a dandelion! It was not until the Cretaceous Period, 113 to 85 million years ago, that flowering plants evolved, but once they did, it was with a bang. Long before even the earliest man walked, they were the dominant plants on earth. To this day, no one is sure exactly why this "explosion" occurred, but it is interesting to note that at the same time bees, butterflies and their many relations first appeared. Without flowers these insects would have a difficult time surviving, and without insects, many flowers would have a difficult time producing seeds. The bottom line is that flowers exist for just one basic reason—to accomplish pollination by insect visitors or by wind dispersal of pollen and thus assure the production of seeds.

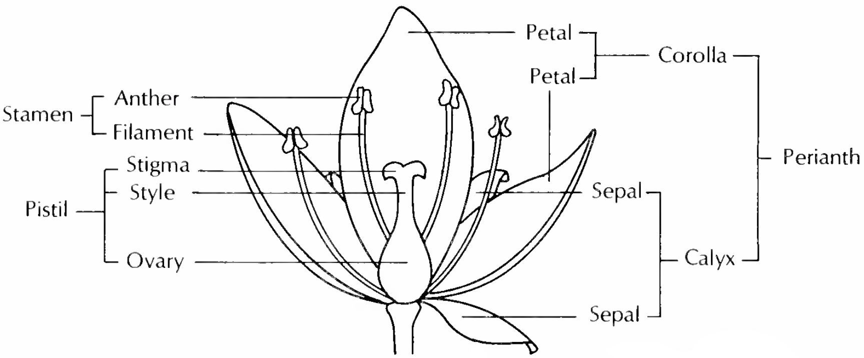
All flowers are made up of the same basic parts (p. 46); the incredible diversity we see in flowers is a function of the shapes and arrangement of these structures. The structures vary to give each species of flower some edge in achieving pollination. In this article I will try to show how close examination of the structures of flowers can tell you something about their strategies for survival and perpetuation.

In the majority of flowers the most spectacular structure is the petals, or corolla. Flamboyant corollas serve to advertise the flower to potential insect and animal pollinators. There are often markings, called nectar guides, on the corolla which work in concert with the shape of the flower to direct the movements of the visitor toward nectar, and in the process toward the sexual structures where pollination actually takes place.

Flower structures may be very different from those shown in the idealized flower (below). For instance, what appear to be six petals in a tulip flower are actually three petals and three sepals. In an iris flower, the topmost portion of the "fall" is actually a modified style and stigma. The white "petals" of an ox-eye daisy are, in fact, single flowers, sterile and modified for attracting insects. The yellow center of a daisy is made up of the hundreds of tiny fertile flowers.

Whatever the arrangement of the parts and their physical appearance, their final purpose remains the same—to receive pollen from, and disperse pollen to, other flowers. In many cases this is done by placing pollen on the body of a visitor. Plants have developed many ingenious ways to accomplish this. Mountain-laurel (*Kalmia latifolia*) is spring-loaded, its pollen-bearing structures (anthers) held back in niches in the corolla until a pollinator alights, releasing the tension, and throwing the anthers forward in a movement that cannot help but hit the visitor. Asiatic bucket orchid (*Paphiopedilum* spp.,), a relative of our native lady's slipper orchid, employs the unusual technique of trapping the pollinator and forcing it to crawl to freedom through a long channel. The lip petal of this orchid is modified into a cup with an extremely slick surface. Bees are attracted to the flower, try to alight, and slip into the cup, where they cannot get a purchase to walk or fly away. Thus trapped, the bee must crawl along the only rough surface offered, a tunnel up the back of the flower. Here it first contacts the stigma, and then the anther, depositing pollen at the first, and picking up a new load at the second. For the orchid this trap technique has the added advantage of saving the expense of producing nectar. Nectar serves no purpose in flowers except to attract pollinators and in terms of plant energy is costly for the plant to produce.

The pollination strategies of flowers are as varied as the plants themselves. In a few, rare cases plants have evolved that are wholly dependent upon the services of one particular species of pollinator. For example, the Mediterranean *Ophrys* orchid has evolved to closely resemble the female of one species of wasp. It can only be pollinated by the male *Ophrys* wasps. The males, hatching out a few days before the females, try to copulate with as many orchids as they can find and pollinate them in the process. The Christmas Star orchid (*Angraecum sesquipedale*) of Madagascar has a 12-inch spur, and, as Darwin predicted forty years before it was confirmed,



Redrawn from author by K. Kling

Figure 1. The basic structures of a flower

S. Wertheimer

The bucket-shaped lip of a *Paphiopedilum* sp. orchid.

it is pollinated by a moth with a 12-inch tongue. Closer to home, yuccas are totally dependent on the yucca moth, which is in turn entirely dependent upon the yucca plant, both for its sustenance and as a place for egg-laying and larval development. The vast majority of plants, though, are far more flexible regarding pollinators. In the semi-arctic Faeroe Islands flowers that in more temperate climates are normally served by bees are pollinated by flies. In autumn jewelweed is frequently pollinated by migrating hummingbirds in lieu of the usual bumblebees.

Nonetheless, certain traits in flowers are characteristic of adaptation to certain types of pollinators. To increase your enjoyment of flowers, their adaptations, and the reasons for them, short descriptions of these traits are given below. Bear in mind that these are only general patterns—by no means, for instance, do all butterfly-pollinated flowers show all the traits mentioned, nor are classic butterfly-pollinated flowers immune to successful visits by pollinators other than butterflies.

Wind pollination. Most grasses and the majority of trees found in the northeast have flowers that are wind pollinated. These flowers produce tremendous quantities of pollen because of the imprecise way in which their pollen is transported. The pollen tends to be released on warm, dry days, when there is the least chance of it being washed out of the air by rain. (This explains why your hay fever is better after a storm.) These flowers are usually bisexual and have no perianth (corolla) or scent, since they have no need to attract pollinators.

Beetles. Beetles were important pollinators at the time flowers first evolved, although they do not frequently provide the service today. Because beetles are clumsy fliers with smooth bodies that do not readily hold pollen, the only flowers that they can effectively pollinate are large and open, with quantities of easily accessible pollen; magnolias are an example. Flowers that beetles are known to visit generally also have strong odors and tend to be greenish-to-off-white, and without nectar guides.

Flies. Like beetles, flies are not commonly pollinators. Flowers they are known to pollinate tend to bloom at odd times of the year (like English ivy) or in harsh climates (like the Faeroe Islands), thus decreasing the flies' competition with bees. These flowers tend to be small, of dull colors and with no noticeable scent. In addition, there is a small, distinct group of flowers adapted to pollination by carrion flies. These blossoms are often trap flowers, dull, dark browns and purples, or greenish, and are frequently mottled. They produce no nectar and have a strong scent of decaying meat. Blossoms of this type can be found in several flower families, but all are commonly called carrion flowers. The Latin name of our only native one is *Smilax herbacea.*

Bees. By far the majority of flowers, particularly in temperate climates, are adapted to pollination by one or more types of bees. These flowers are of a variety of colors. Red is less common, since bees cannot see this color, though they may visit flowers we see as red if they have ultraviolet patterns (see p. 10). Blue and yellow flowers, usually with nectar guides, are favored. They tend to have fresh scents and moderate quantities of nectar.

Butterflies. Butterfly-adapted flowers also come in many colors. Their hues are usually vivid, including the pure red not seen in bee flowers. Scents are weak, but pleasant. Because butterflies have very long tongues and a natural instinct to use them to probe narrow spaces, the abundant nectar of butterfly flowers tends to be hidden at the end of long, narrow tubular flowers or spurs. Blossoms tend to be erect, with corollas that form handy landing platforms. Lantana, cardinal flower, and the flowers of the aster family are favored by butterflies.

Moths. Most species of moths are nocturnal, so moth flowers tend to open at night. It is at this time that they often produce strong, sweet odors. The flowers are usually white, though sometimes drab or with insignificant corollas. The petals are often fringed and curved back out of the way, since most moths feed while hovering, the same reason the flowers are generally horizontal or pendant. As with butterfly flowers, moth flowers often are long, narrow tubes or have spurs. They have no nectar guides and produce large quantities of nectar. Many lilies are moth pollinated, as are tuberoses and daturas.

Birds. Hummingbirds, the sunbirds of Africa and the honeyeaters of Australia are all generally dependent on flowers for their food and, so, are common pollinators. Hummingbirds, though, are the only pollinating birds found in the northeastern states. Taken individually, flowers adapted for birds are probably the most spectacular of all. They are most often scarlet, frequently with brilliant splashes of other colors. The flowers tend to be wide tubes with hard walls able to withstand being probed by a hard beak, and hummingbird flowers are usually horizontal or pendant, with curved-back margins to accommodate hovering. As with moth flowers, hummingbird flowers have large quantities of nectar, which is needed by hummingbirds to sustain the energy demands of hovering. Bird flowers are generally without scent, as birds have very little sense of smell. Trumpet creeper and poinsettias are both pollinated by hummingbirds.

Bats. Some bats feed almost exclusively on the nectar and pollen of a few specially adapted plants. These bats are most common in the tropics, but during the summer they may range as far as the American southwest where they feed on the nectar of century plant (*Agave* spp.) and some cactus flowers such as those of the saguaro (*Carnegiea gigantea*). These flowers open at night, when bats are active. They are often pendulous and outside the foliage, making them conspicuous to the sonar that bats use to locate food. Usually drab brown or purplish, they are sometimes whitish, and are either large, strong single blooms or compact "brushes" of small flowers. Because these bats also feed on fruit, the flowers often have strong scents reminiscent of fermenting fruit. They offer the largest of all nectar rewards, and have copious pollen, needed to support a pollinator as large as a bat.

The shapes that flowers have developed over the last 100 million years or so are not random. Although our appreciation of them keeps the many horticultural industries alive, their real purpose is to help accomplish the continuation of their species. It is simply our great good fortune that the enticement of pollinators is achieved through shape, color, scent and the many other factors that combine to produce the beauty of a flower.

HOW BEES AFFECT THE EVOLUTION OF FLOWERS

Robert A. Askins

To understand flowers, you should follow the path of a bee as it works its way across a garden or meadow. Either a yellow-and-black striped bumblebee or an orangish honeybee will do. Choose a single worker and chase it from flower to flower, noticing the species of each flower where the bee takes nectar or pollen. In most cases a clear pattern emerges. In a wet meadow with a mixture of flowers—jewelweed, Joe-Pye-weed, boneset, red clover and goldenrod—a particular bee may only visit jewelweed, while another bee flies over the orange jewelweed flowers and drops down only on white boneset flowers. Each worker specializes in a particular type of flower; it has a "major." As I will describe below, this peculiar habit of bees explains much about the beauty and diversity of flowers.

Specializing for Efficiency

But first, why do bees have majors? Insight comes from watching a novice worker, a bee that has never foraged before. Bernd Heinrich[1] did this by watching a small colony of bumblebees he had placed in a large cage built over a patch of boggy meadow. The cage enclosed a variety of flowers. He had glued a tiny, numbered tag on the back of each worker in this colony, so he knew which bees were experienced foragers and which bees had recently emerged from cells and were foraging for the first time. He found that on its first foraging trip, a bee does not have a major. Typically it visits several species of flowers, and its efforts to find nectar inside these flowers are clumsy and often unsuccessful. Novice bees have particular trouble mastering the intricate structure of flowers such as jewelweed (*Impatiens capensis*) and turtlehead (*Chelone glabra*). They tend to climb around the top of the flowers without finding the opening into the flower and they probe for nectar in inappropriate places. By its seventh foraging trip, however, a worker has usually specialized in a particular flower species and efficiently manipulates this flower to reach and gather the nectar. This occurs through a process of trial and error as the bee tries different approaches to feeding on a particular kind of flower. The function of having a major becomes clear: complex flowers usually have more nectar than simple flowers, but bees must learn how to use them. Once a bee has mastered a particular kind of complex flower, it can gather more nectar in a shorter period of time by specializing in this flower. In one experiment[2] it was found that for inexperienced bumblebees, feeding on a larkspur flower (*Delphinium barbeyi*) required about 19 seconds. Bees that had previously foraged on larkspurs for a short time in captivity required only 9 seconds, while wild bees in the field foraging on the same species of flower finished in only two seconds. Apparently the wild bees were even more experienced in using larkspurs than the captive bees. Thus acquiring experience with a particular type of flower can result in a dramatic increase in the nectar-gathering efficiency of a bee.

Because learning how to gather nectar or pollen from a flower occurs by trial and error, it is not surprising that different workers develop different solutions to the same problem. Two workers may use distinctly different techniques to acquire nectar from the same species of flower. For instance, in many flowers visited by bees, the petals form a long nectar spur. Some workers reach the nectar at the base of the spur by crawling into the opening of the flower while others land on the outside of the spur and chew a hole through it. The latter technique is called "stealing" because the flower loses nectar without being pollinated.

A novice bee may attempt to feed on many different types of flowers, and its final choice of a major is not solely a matter of which flower it happens to master first. If a flower contains relatively little nectar, the bee will learn to avoid that species. Also, several different species of bees may forage in the same meadow or garden, and different bee species tend to major in dif-

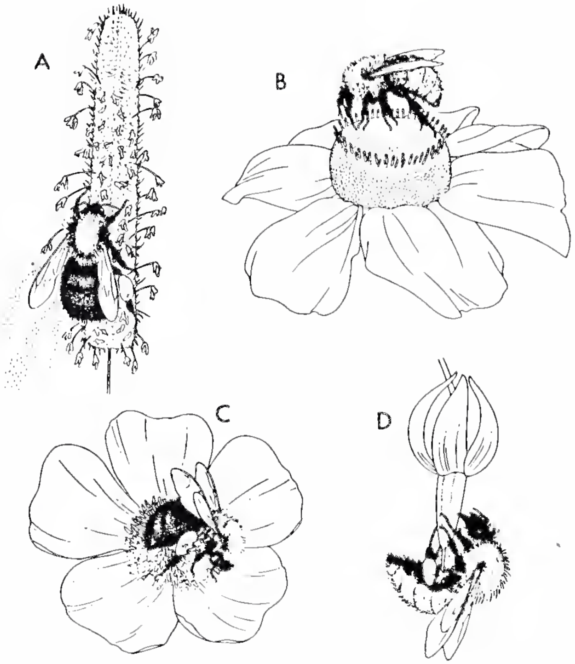
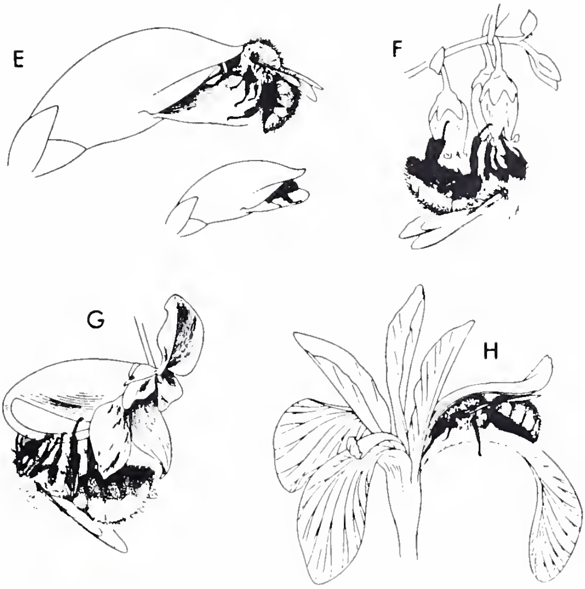


Fig. 1. Foraging methods used by bumblebees at different types of flowers. (A) Walking up grass (*Pleum*) flower collecting pollen; (B) collecting nectar from a composite flower; (C) vibrating groups of anthers to collect pollen on a rose (*Rosa*); (D) vibrating a bittersweet nightshade (*Solanum dulcamara*) with legs and mandibles to shake pollen loose; (E) entering a turtlehead (*Chelone glabra*) flower for nectar; (F) collecting nectar from blueberry (*Vaccinium*); (G) "stealing" nectar from jewelweed (*Impatiens capensis*); (H) sipping nectar from iris (*Iris*). (From "Foraging Specializations of Individual Bumblebees," by Bernd Heinrich. © 1976, Ecological Monographs 46:105–128. Reprinted by permission.)

ferent types of flowers. The choice of major often depends on the size and structure of the bee. Long, tubular flowers are favored by bumblebee species with long tongues, while short-tongued species normally favor shallow or open flowers.[3] This separation may even occur among workers of the same species because bumblebee workers vary greatly in size. The largest workers in a colony are twice the size of the smallest workers, and large workers may use flowers or techniques not used by small workers.[4] For instance, in alpine meadows in Colorado larger workers of a particular bumblebee species (*Bombus flavifrons*) tend to visit larger flowers, such as larkspur (*Delphinium barbeyi*), while smaller workers visit smaller flowers, such as bluebell (*Mertensia ciliata*).[5] Also Margaret Carroll, Marshall Stark and I recently found that large workers of a particular bumblebee species (*Bombus vagans*) in Connecticut "steal" nectar from jewelweed while small workers reach the nectar by entering the flower opening. The largest workers seem to be too large to fit into the opening. The entire colony probably benefits from the variability among workers. Foraging workers gather nectar and pollen for the brood and the other adults in the hive. Different workers are suited to work best with different types of flowers or with different techniques, so the colony can tap a wide range of food sources.

Honeybees also have majors, and Karl von Frisch[6] discovered that honeybees with the same feeding specialty cluster together in the hive. An advantage to this clustering



may be communication. When they find a good food source, honeybee workers return to the hive and do a "waggle dance," an elaborate series of movements that indicate the direction and distance to food. It would obviously be an advantage for workers with the same major to gather in one part of the hive so that they can communicate about the location of their preferred food source.

A disadvantage to specializing in one flower species is that it can suddenly go out of bloom; for instance, an early frost can eliminate jewelweed overnight. This is probably one reason that most workers not only have majors, but also "minors," flowers that are used infrequently but consistently. A minor also allows bees to monitor the amount of nectar in at least two species of flowers. If the minor has more nectar (perhaps because nectar production in the major has declined) the bee can switch its specialization to the minor. Bernd Heinrich added artificial nectar to aster (*Aster novae-angliae*) flowers, and bees that had minored on this species quickly made it their major[7].

Bees and Evolution

The tendency of bees to specialize has a direct impact on the evolution of flowers. Pollinators and flowers depend upon one another. Flowers produce energy-rich food (nectar) to attract pollinators, and pollinators transfer pollen, containing sperm, from one flower to another, effecting cross-fertilization. Flowers have many adaptations to ensure that pollen is transferred (see p. 45), but one of the most effective ways is to attract pollinators that specialize in one type of flower because this greatly increases the chance that pollen will be transferred to another flower of the same species. Less selective pollinators waste pollen by carrying it to other species of flowers. Attracting specialist bees requires special qualities: a complex shape and large nectar reward to provide the challenge and incentive that lead to specialization by individual workers, and a distinctive color and scent so that individual bees can readily recognize their preferred flowers. Bee-pollinated flowers come in a great variety of colors, and many (daisies, for instance) have distinctive patterns that show up in the ultraviolet area of the spectrum. (Bees can see this color, but it is invisible to us except with ultraviolet-sensitive film.)

Thus flowers have evolved particular features that facilitate specialization by bees. Much of the beauty and variety of flowers —the diversity of color, scent and shape—

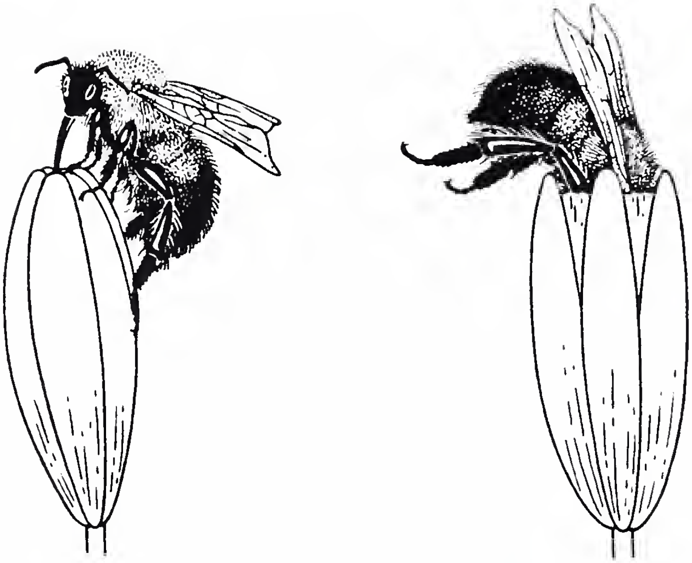


Fig. 2. A bumblebee reaches the nectar in a closed gentian by prying apart the pleated blossom and squeezing the front of its body inside. Complex techniques of this sort must be learned by trial and error. (From *Bumblebee Economics* by Bernd Heinrich. Harvard University Press, 1979. Reprinted by permission.)

results from this ancient relationship between flowering plants and specialist bees. In many other groups of pollinators, however, individuals do not specialize in particular species of flowers. Flowers that depend on these pollinators may also be colorful, but they are not as diverse. For instance, most flowers that depend on nocturnal moths are white, while most flowers pollinated primarily by hummingbirds are red. Since individual pollinators do not show strong preferences for particular flower species, there is no advantage to distinctive coloration in these flowers. In fact, flowers pollinated by the same group of nonspecialist pollinators tend to be the same color, the color that the pollinators see or respond to best.

Bumblebees and honeybees are important pollinators in high mountain meadows, on the floor of deciduous forests in early spring, and in late-summer fields in New England. During the peak growing season these landscapes are sprinkled with the reds, blues, purples and yellows of bee-pollinated flowers. Because the colors, scents and shapes of bee-pollinated flowers are exceptionally diverse, it is not surprising that some of the most spectacular floral displays in nature occur where specialist bees are the dominant pollinators.

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VEGETATIVE (NONSEXUAL) PROPAGATION

Stephen K-M. Tim

Theophrastus, (born about 370 BC), the Greek philosopher and pupil of Aristotle, provided one of the earliest written directions for propagating plants vegetatively. He advised that one "sharpen a stout shoot [of the fig tree] and drive it with a hammer, till only a small piece of it is left above ground, then piling sand above so as to earth it up." Today, cuttings of plants continue to be made using techniques that are perhaps slightly more refined than such a no-nonsense approach.

The practical methods of vegetative propagation are well known and practiced by many gardeners (see P&G Handbook #103, *Propagation*). This article will describe the changes which take place as cuttings root, and the conditions required for their well-being. A similar treatment of the grafting process will follow.

Cuttings

Plants are able to regenerate tissues and organs in the form of adventitious buds and roots. This is because of the ability of each cell to grow into a complete organism, a quality called *totipotency.* While this condition is exploited most effectively in tissue culture (see p. 60), here the treatment is in a more defined sense, namely the induction of roots in stems, shoots in roots, and both roots and shoots in leaves.

The main reason for propagating plants vegetatively is to perpetuate a plant and its specific qualities. It is a method of *cloning.* In contrast, plants derived from seeds are not identical as they have come about by the reshuffling of genetic traits when nuclei of sperm and egg fused at fertilization.

Stem cuttings. This type of cutting is a length of stem which is inserted into a rooting medium. Under the correct conditions, roots and shoots form and the new plant is able to survive independently.

An introduction to basic anatomy will help in understanding the changes which take place in all forms of stem cuttings. In a cut taken through an herbaceous or woody stem, a clear, usually lighter layer can be seen just below the bark (Fig. 1). This is the *cambium,* a layer of actively dividing cells where new cells of the plant's conducting system are formed. When bark is eased away from the underlying woody parts of the stem separation occurs through this delicate cambium layer.

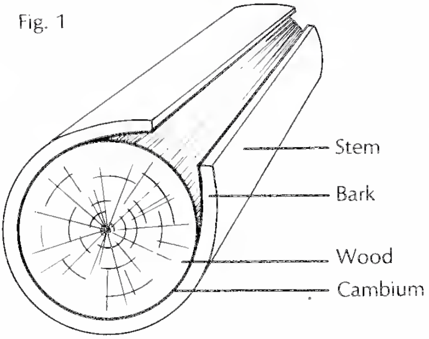
In response to the wound inflicted when the cutting is prepared, cells from the cambium grow out in the direction of the cut surface, especially on the lower end of the shoot. This is called the *callus* which may eventually cover the cut end completely. Even then, it retains a ringlike appearance (Fig. 2).

If any function can be ascribed to the callus, it is the sealing and protection of the cut end. From the point of view of the propagator, its appearance signals the good health of the cutting. The callus has also been credited with giving rise to the new roots, but when this happens it is the exception rather than the rule. Roots arise mainly from the actively growing cells *close* to the cambium and grow out from around the callus (Fig. 3). In a few cases, they arise even further away. An example is in *Crassula* where roots are produced near the bark.

Many propagators still prefer to have the lower part of the cutting made below a node. In general, rooting is probably better from this area because of the higher incidence of *root initials* (cells which can give rise to roots) at the nodes. Similar reasoning is used when taking cuttings with a heel. Here, a side shoot is pulled away from the main stem, tearing off a sliver or heel of the older nodal wood (Fig. 4).

Root cuttings. Not all plants can be propagated from root cuttings. Those that can be include the flowering quince (*Chaenomeles* spp.), the Oriental poppy (*Papaver*

Fig. 1



orientale), and the raspberry and blackberry (*Rubus* spp.).

Both cut ends of the root form prominent callus. The callus at the upper end is the most important because it is from this tissue that adventitious buds originate. Strange as it may seem, rooting a root is not a simple matter. If new roots appear, they are from pre-existing initials. It is rare but not impossible for new roots to arise. What invariably happens is that roots are produced from the base of the newly developing shoot, and the old root cutting eventually shrivels away (Fig. 5).

Leaf cuttings. Only certain plants have the ability to regenerate buds and roots from leaves. In the case of the India rubber plant (*Ficus elastica*), its leaves will produce roots from the cut end of the leaf stalk (*petiole*) but buds will fail to form unless the axillary bud (the bud on the stem at the base of the leaf) is included when taking cuttings.

In the African violet (*Saintpaulia* sp.) the roots first grow out from the center of the cut petiole close to the conducting

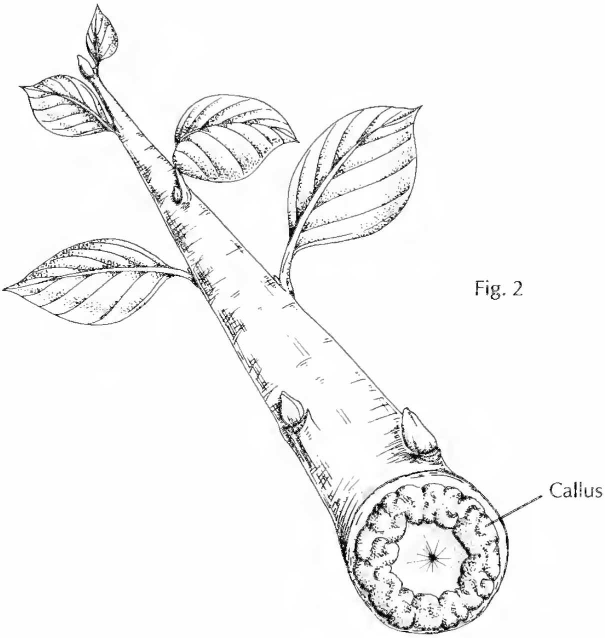
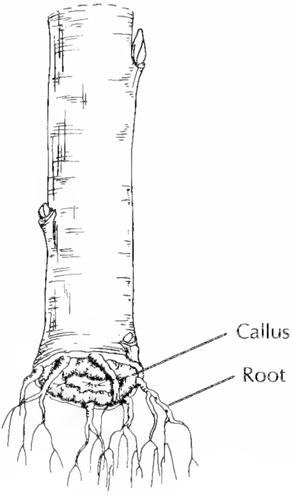


Fig. 2

Fig. 3



Drawings by S.K–M. Tim

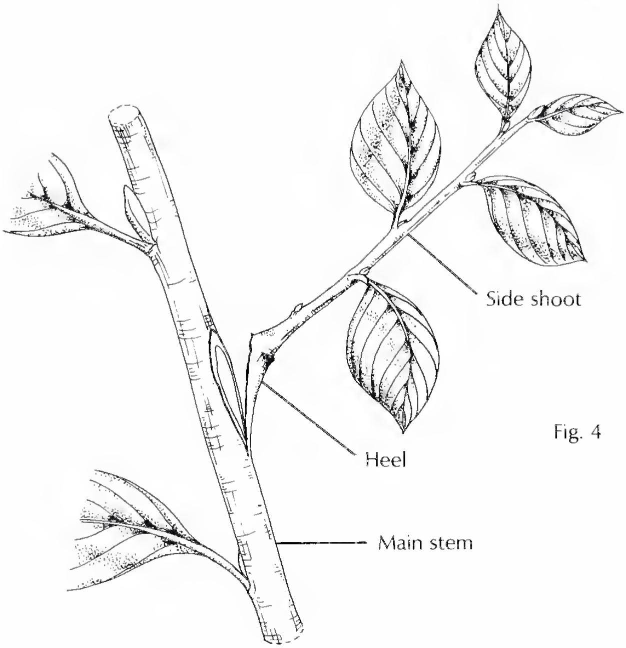
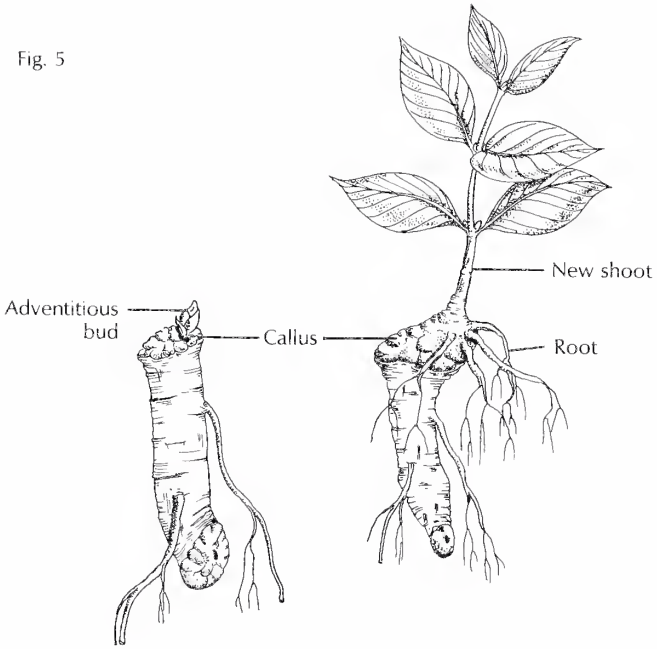


Fig. 4

Fig. 5



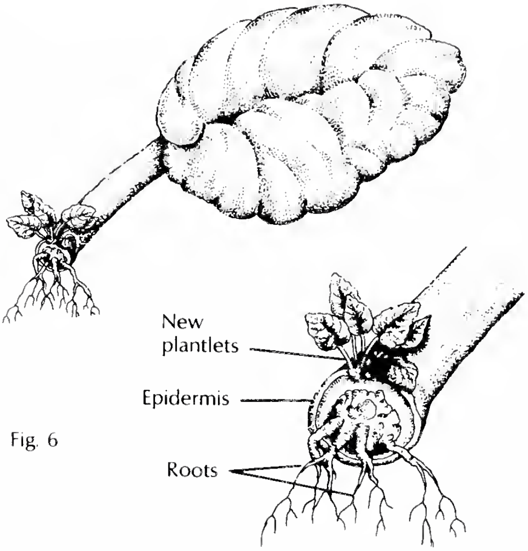


Fig. 6

tissue. Buds ultimately appear near the outer cell layer (*epidermis*) (Fig. 6). The cut petiole in *Peperomia* sp. thickens and may even appear to have an overgrowth of callus tissue. Both buds and roots issue from this.

Hormones To Promote Rooting

Growth and development in plants is carefully synchronized by the action of naturally occurring hormones. Whether the development of buds, the initiation of roots or the germination of seeds, these are all regulated by hormones acting in response to the environmental conditions to which the plant is exposed.

Actively growing buds and young leaves are the sites for the synthesis of the growth hormone, *auxin,* or IAA (indole-3-acetic acid). In the case of a cutting, when this auxin diffuses down the stem the higher concentration at the top stimulates bud or shoot development, while the lower concentration at the bottom initiates root development. The cutting thus shows definite polarity and, even if the cutting is inverted, shoots will grow from the natural top and roots from the opposite end.

A certain concentration of the auxin has to accumulate in the lower end of the cutting before roots are initiated. In practice, the natural auxin is augmented by the application of synthetic auxins. Two such auxins are IBA (indolebutyric acid) and NAA (naphthaleneacetic acid) which have proved stable and effective as an assist to the naturally occuring auxin.

Environmental Conditions To Assist Rooting

The successful rooting of plants depends upon suitable conditions around the cuttings.

Rooting medium. A rooting medium or mixture does more than merely prop up the cutting. Above all, it should be porous to provide fast (sharp) drainage. A popular mixture consists of sand, or sand and perlite, and provides the required good drainage; this reduces the chance of the cuttings being kept overly moist and possibly drowning or rotting. It also allows for the easy circulation of air, so important for the changes which take place in the cuttings. New tissue growth, whether for roots or shoots, involves the manufacture of protein. This, in turn, is dependent upon the respiratory process for which oxygen is essential.

Peat, preferably sphagnum peat or coarsely-milled sphagnum moss, is often added to the medium. This raises the moisture holding capacity of the porous medium but more importantly, stabilizes the acidity of the medium from slightly acid to neutral, (that is, a pH of 6.5 to 7.0), which is most conducive to rooting.

Light and humidity. Except for hardwood cuttings which are taken during dormancy, cuttings need light to create roots. Auxin, synthesized in the buds and leaves of the cutting, requires the presence of carbohydrates (starch and sugars) in the tissues for the initiation of roots. These carbohydrates are a product of photosynthesis, a process where light, usually sunlight, reacts with the plant's chlorophyll.

Since the cuttings have no roots to absorb water, they must be protected from drying, especially in bright sunlight. A protective enclosure of plastic or a propagating frame of glass or polyethylene must be used to maintain humidity around the cutting. "Mist propagation" is a technique used in greenhouses where intermittent fine mist is sprayed over cuttings.

Temperature. A host of physiological processes, leading to cellular growth, involves temperature-sensitive enzymes. An average temperature of 75 °F must be maintained in the medium to encourage rooting. Hence, propagating frames are often placed above heating pipes in greenhouses or electrical cables are used to provide the necessary warmth. The air above the cuttings can be kept slightly cooler to reduce water loss from the cuttings.

Grafting

Grafting in plants was known to the Chinese as early as 1000 BC and Aristotle wrote most knowledgeably of this practice. Trees in the wild could well have provided the first clues to the ability of plant stems to form graft unions with each other. Certain trees, such as the beeches and hollies, invariably have some crossed trunks, firmly bonded together by enmeshed tissues.

Not all plants lend themselves to grafting. It is the majority of herbaceous and woody plants, members of the cone-bearing Gymnosperms and the Dicotyledons in the Angiosperms, which are most successfully grafted because they have a distinct cambium. Grafting between roots is also possible but this process is of minor application in gardening and will not be covered here.

Grafting requires that at least two plants be brought into close contact, enabling their tissues to unite; their continued growth is as that of a single plant. The part bearing the roots is called the *stock,* and that which is to become the upper, dominant part, the *scion* (pronounced sigh-on). At the time of grafting, the scion can be a length of stem with many buds or just a single bud, the latter, called budding, is used especially in rose propagation where the plant with good flowers may have weak or tender roots.

The success of a graft depends on the natural relationship of the plants. Preferably, the plants should be from the same clone. The process is not always possible even among species within a genus and that between plants from different families is, thus far, virtually impossible. Years of research have provided few answers to why some grafts are incompatible and fail. Pears and quince are in the same family but pears usually cannot be grafted onto quince roots. Quinces contain a substance which, in the area of the graft union, is converted into hydrocyanic acid (cyanide) by the action of enzymes in certain pears. This cyanide interferes with the normal growth of tissue between the grafts and water is not able to pass freely between stock and scion. Failure results in such cases. Where grafts were successful, it was found that the pears used contained a chemical inhibitor which blocked the release of the cyanide.

Techniques in grafting are many and varied. A representative range is illustrated in Fig. 7. For the operation to be a success, as many sites as possible of the cambia of the stock and scion must be brought into contact or close proximity. Trying to match all the cambial tissues exactly is almost impossible and unnecessary.

Soon after the two parts are positioned together, the tissues adhere to each other by a secretion from the intact cells closest to the cut surfaces. Cells immediately associated with the cambia of both plants then divide actively, filling the spaces between the stock and scion. As in the case of cuttings, this new growth of tissue is the *callus* and in the grafting process, is produced entirely after the two parts are brought together (Fig. 8d). At no time is there an exchange or intermingling of cell contents.

The callus allows for a limited passage of water between the two parts but this next phase is essential for ensuring the perma-

Fig. 7

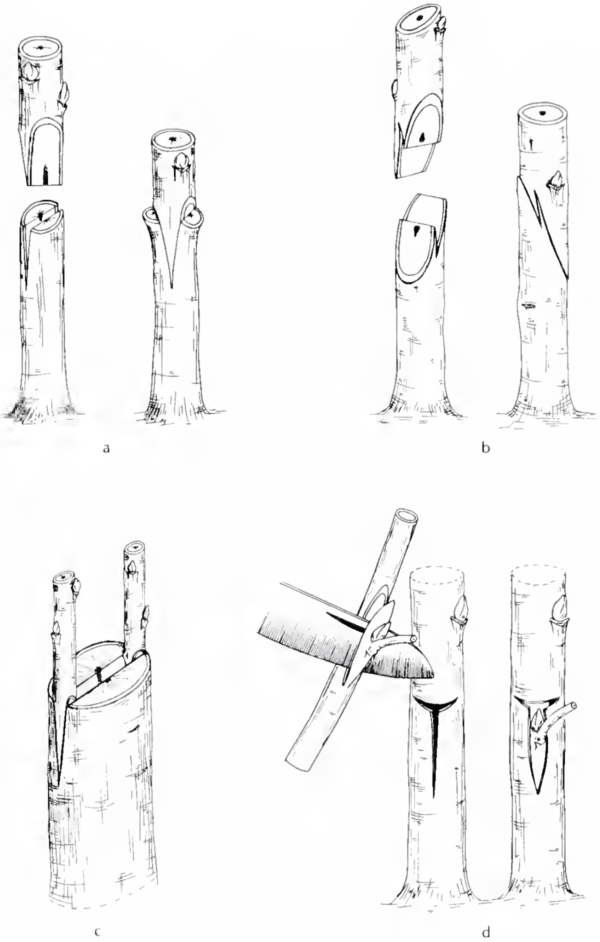


Fig. 7: a. wedge graft; b. whip-and-tongue graft; c. wedge graft (double); d. T-budding.

nent union between stock and scion. The callus cells adjoining the cambia of stock and scion then become organized into a cambium (Fig. 8e) and take on the function of this vital tissue. Active divisions of the now-united cambium result in cells being produced outwards and inwards from either side of this tissue. These cells make up the conducting system and are continually being renewed by further divisions of the cambium (Fig. 8f). Water, nutrients and also food from photosynthesis are freely exchanged between the grafted parts, and the stock and scion function as one. The swelling of buds on the scion soon herald the success of the graft.

Environmental conditions. Proper callusing in the grafted area requires certain conditions. At the beginning delicate callus cells are particularly susceptible to drying out and attack by pathogens. Hence, grafted parts are often waxed after being tied together. Grafts can also be kept in polyethylene tents to provide humidity until tissues knit.

Callusing also involves active cell division with a high rate of respiration, requiring oxygen, providing the necessary energy. In some cases, as with the grape, free access to oxygen is necessary. Here, waxing of the graft union must be avoided, because the wax blocks oxygen from reaching the developing tissues.

The season for grafting is also significant. The warmer months, with temperatures between 40°F and 90°F, are best

Fig. 8

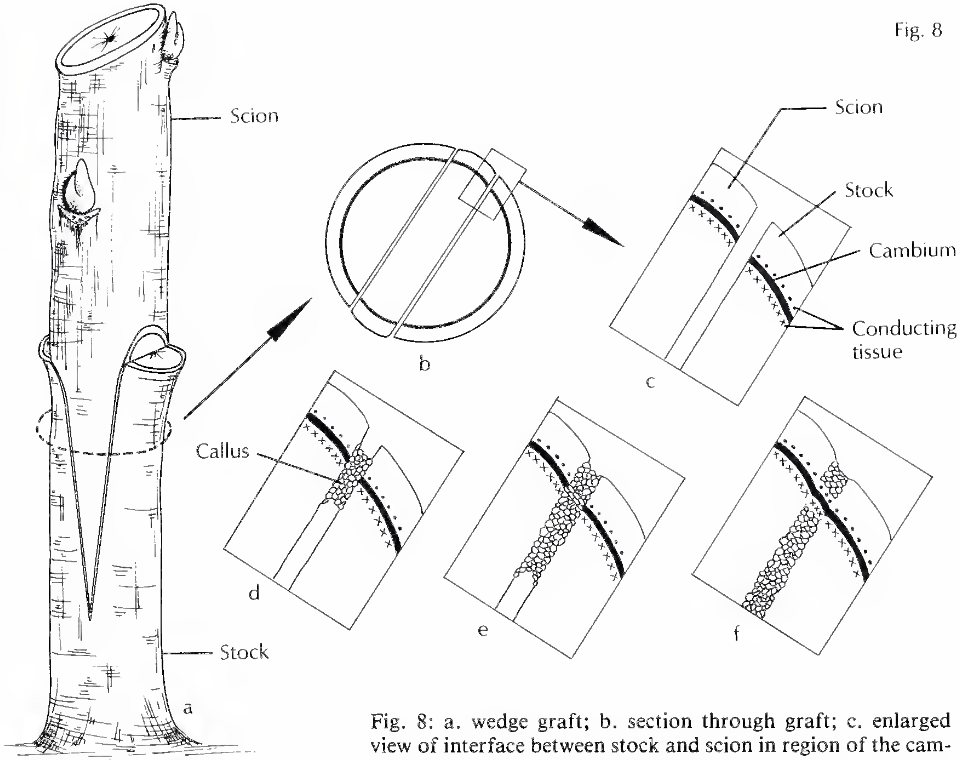


Fig. 8: a. wedge graft; b. section through graft; c. enlarged view of interface between stock and scion in region of the cambium; d. development of callus; e. callus cells become organized into cambium; f. cambium and conducting tissue of stock and scion continuous.

because the chemical reactions in cellular respiration, so essential for tissue growth, depend upon the action of temperature-sensitive enzymes. When the bark comes away from the wood cleanly, it signals that the best time for budding and bark grafting has arrived.

Grafting and auxins. While auxins and other growth substances stimulate the growth of callus, these are not normally used in grafting.

Practical reasons for grafting. Grafting has been commonly used to propagate difficult-to-root plants, but perhaps its most useful application is in introducing specific qualities to the scion. These include size restriction (dwarfing, for fruit trees especially), promotion of vigor, increase in fruit size and yield, modification of growth form, disease resistance and so on.

Since cell contents are not interchanged in a graft union, no genetic changes can occur.

Most work in the stock/scion influence has focused on the size-controlling effect of certain rootstocks. There are indications that the graft union restricts the flow of water, nutrients and minerals. In cases involving apples where a nondwarfing apple stock promoted vigorous growth in the scion, three times as much phosphorus and calcium were transferred to the scion than was transferred from a dwarfing stock. Some dwarfing stocks may also be limited in the production of growth-promoting auxin and gibberellin. Evidence is also forthcoming that certain dwarfing rootstocks contain enzymes which break down growth-promoting IAA (indoleacetic acid), and the overall effect is the dwarfing of the top growth. In yet other cases, growth inhibitors were found in certain dwarfing rootstocks.

It seems logical to conclude that the effects of the stock on the scion are due to several factors rather than any single one. ❧

Tissue Culture and Meristem Propagation . . .

BREAKTHROUGH ADVANCES IN PROPAGATION

Philip V. Ammirato

The last twenty-five years, and in particular the last ten years, have witnessed a dramatic increase in our ability to propagate plants using a broad range of techniques collectively called "plant tissue culture." We have been able to do so by utilizing the inherent ability of higher plants to regenerate, to make more of themselves. Shoot apical meristems (the hundred or so cells at the very tip of an actively-growing shoot or root) produce a continuous supply of leaves, stems and lateral or secondary shoot apices that can grow out to produce branches. Root apices produce secondary roots. Plants can also produce adventitious organs. "Adventitious" comes from the same root as "adventure" and generally means we are "surprised" to find something, such as the production of roots on stems or shoot buds on roots. In addition, plant cells often have an ability to resume growing even after they have stopped. For example, cortical cells will resume dividing to become a phellogen or cork cambium and produce the corky layer on trees. Plant biologists have been able to tap these responses and do dramatic things with them.

The key to plant tissue culture is aseptic (sterile) technique. The nutrient or culture medium that is needed to grow the plant cells contains salts, sugars, vitamins and sometimes plant growth regulators or hormones. Should microorganisms or fungi be present, they will grow faster than the plant cells and overwhelm the tissue; therefore, all extraneous organisms must be eliminated and this requires aseptic technique. It is perhaps the most demanding part of the operation for everything must be sterile or free from contamination. The medium and all equipment must be sterilized, often by placing in an autoclave (a type of pressure cooker) and the plant itself must be cleaned of all organisms. Luckily, most internal tissues of plants are free of microorganisms and only the surfaces must be cleaned; this is termed "surface sterilization." (There are exceptions to this, however, and endogenous microorganisms can cause unexpected trouble. It is something to keep in mind when attempting to grow plants in culture.) For most plants, however, a treatment with dilute commercial bleach (sodium hypochlorite) followed by rinses in sterile water will remove contaminants. Therefore, with the proper medium, aseptic techniques, the right plants and know-how, some remarkable things have been achieved, with even greater accomplishments promised for the future.

Micropropagation

The most fully-realized manipulations to date fall into the category of meristem culture or micropropagation. Most botanists, whether amateur or professional, realize that often one can remove a shoot from a plant, place it into a misting bench and have it root, producing a new plant. This can be done in culture using the techniques discussed on pp. 53–57. It was realized about thirty years ago that a shoot apex removed from a plant and placed in culture would root and form an entirely new plant. Therefore, if you had a plant where only the terminal shoot apex was growing and the others remained dormant, you could excise all the shoot apices, place them into culture, and retrieve plants, one for each apex added. Furthermore, it was realized that if the plant were infected with viruses and only the very top of the shoot apex, the "apical dome," were cultured, the resulting plant was often virus-free. Meristem culture has become a powerful tool in producing virus-free stock plants. A more elaborate procedure is now generally used. The plants are first grown for several weeks at an elevated

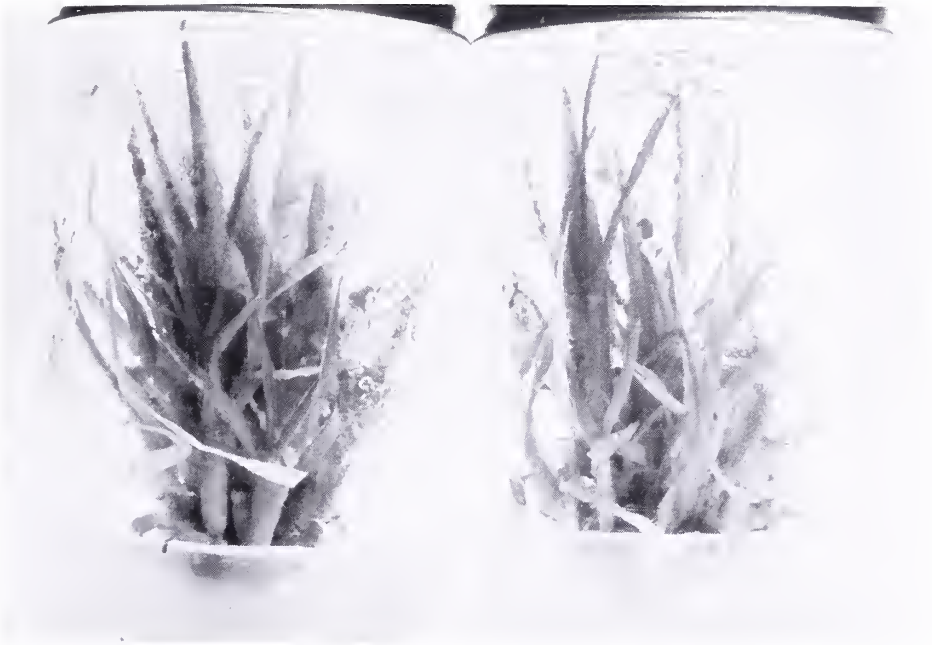


Fig. 1. Sugar cane plantlets propagated by meristem culture and enhanced axillary bud development. (Photographs courtesy of W.R. Sharp and D.A. Evans.)

temperature to partially inhibit virus growth, then the apical dome is carefully excised and the material grown in culture to retrieve whole plants. Finally the plants are subjected to rigorous testing to ensure they are virus-free. Flower production in ornamentals and crop yields in agricultural plants are often dramatically increased by the elimination of viruses.

Soon after scientists realized that shoot apices could be cultured and single whole plants recovered, they discovered that the natural ability of shoot apices to produce axillary buds could be manipulated. With the proper conditions a single shoot apex in culture could be induced to develop many axillary buds precociously. Each one of these could then be excised and rooted. Using this technique many plants could be achieved from one shoot apex. It has been estimated that that clonal micropropagation based on precocious axillary branching could result in a millionfold increase over conventional methods. This discovery has revolutionized the production of many ornamentals. Most of the Boston ferns (*Nephrolepis exaltata* cv. 'Bostoniensis') produced commercially in the United States are propagated by aseptic culture techniques. This is also true of the Gerbera daisies that have made a recent appearance at local florists. Orchids, chrysanthemum, African violets, ficus and rhododendron, to name just a few, now are propagated by meristem culture or ''mericloning.'' The technique is being increasingly applied to crop plants and already is being used for the production of sugar cane (Fig. 1), potatoes, pineapple, taro, yams, strawberry and asparagus. Amateur botanists have discovered the technique and more and more homes have small meristem culture facilities. Courses teaching these techniques have appeared in botanical gardens and universities.

One Meristem, Many Plants

There is more to the story, however. As scientists experimented with the right culture media and conditions to promote shoot growth and shoot proliferation, they discovered that certain treatments would cause the plant cells to divide and grow in an unorganized manner. This mass of

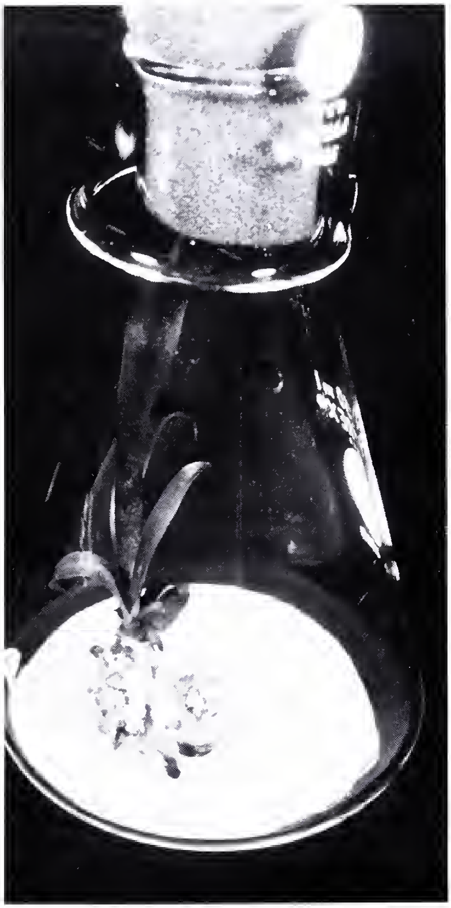


Fig. 2. Snake plant (*Sansevieria*) plants regenerated via organogenesis from callus derived from leaf segments.

rapidly dividing unorganized and basically undifferentiated cells is termed a "callus" and its growth is termed "tissue culture." Since you are not really growing tissues in the biological sense, a synonymous term is "cell culture." The callus can also be placed in a liquid medium and agitated, using one of a number of techniques, producing a "suspension culture." It should be realized that rarely does one grow single individual cells using these techniques. This can be done by using a remarkable technique developed only within the last ten years, termed "protoplast culture." The technique depends upon the use of enzymes derived from fungi to dissolve the cell walls and pectins that surround each plant cell and "glue" them to each other. By doing so, each cell floats freely in the medium giving a true cell suspension or culture. (Removing the cell wall does create new problems, however, for without it the cell itself or "protoplast" will swell and burst. Adjustments must be made in the medium to prevent that.) If the enzymes are removed, the cell walls will grow back and, with the proper conditions, the cells themselves will grow.

Of what use are these new techniques of tissue, cell and protoplast culture? For one, plant biologists have learned that these cells, at least from certain plants, have the ability to stop growing in an unorganized way and start to grow into plants if given the right stimuli and conditions. When cultured, some species will form many shoots from a callus, in a process called "organogenesis" (Figure 2). These shoots can then be rooted, much as with the multiple axillary buds from meristem cultures, and whole plants retrieved. However, in this case, the shoots come from rapidly growing cells and millions of cells can be grown from just a few hundred in a couple of weeks. Many more plants can be propagated using this technique than by mericloning. There are potential problems with this technique, however. Inducing the cells to divide in an unorganized fashion seems to increase the chances that chromosome and genetic changes will occur. Therefore, special care must be taken to prevent changes if the goal is clonal propagation. However, this technique can be useful to produce *desirable* changes, ones that cannot easily be obtained using traditional plant breeding or plant mutation methods. The technique is called "somaclonal variation" (*soma* = body or asexual) and has already produced improved lines of tomatoes and garlic.

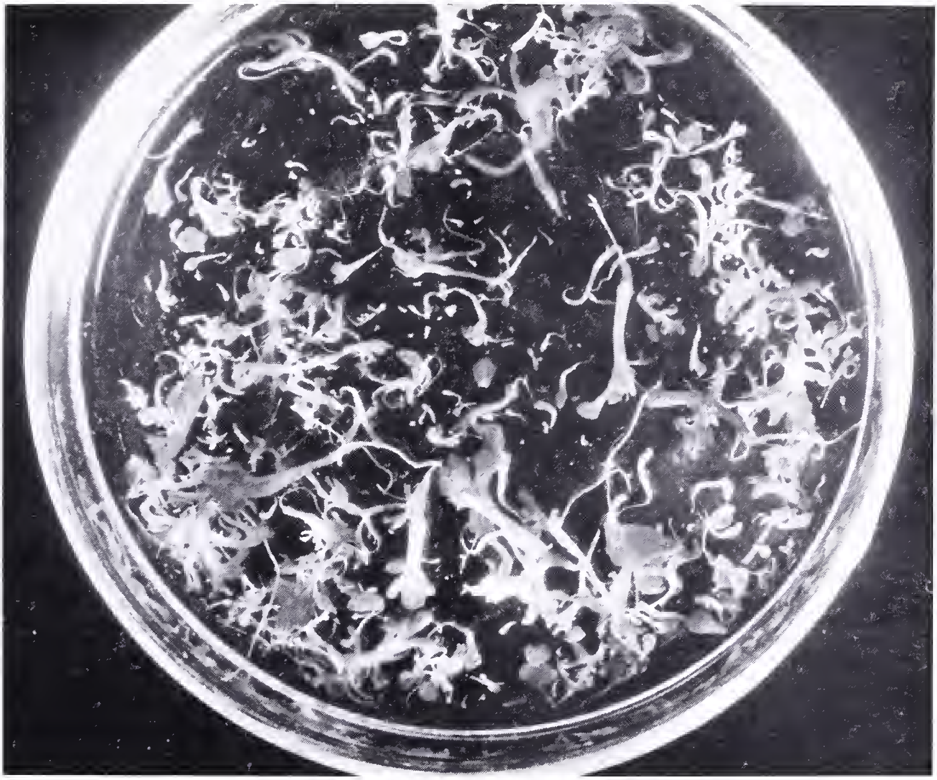


Fig. 3. Numerous carrot somatic embryos grown from a cell suspension in a culture flask and then poured into a petri dish.

There is a second way that cells in culture can regenerate. In a number of species, when the proper signals are given, the cells begin to act like fertilized cells and grow into embryos. Normally, embryos grow via the sexual process with the fusion of a sperm nucleus with an egg cell. These embryos, however, grow from somatic cells and are therefore called "somatic embryos" and the process "somatic embryogenesis." Because cells can rapidly divide in culture to produce millions in only a few weeks, somatic embryogenesis offers the prospect of generating millions of embryos in that time. This technique has been successfully used in cultures of carrot (Fig. 3), caraway, celery, coffee, citrus, papaya and the daylily (*Hemerocallis*). These tiny embryos are complete, each containing a shoot apex and a root apex. They float freely in the medium. Their growth in large numbers raises the prospect of artificial seeds. This suggests the possibility of producing millions of somatic embryos that could be coated or encapsulated to produce millions of artificial seeds that could be stored, shipped and planned just like regular, zygotic seeds (Fig. 4). There is still much work to be done but the prospects are intriguing. At this time, however, there are a fair number of plants where many copies can be made either by organogenesis or embryogenesis and, more and more, we are seeing the use of these techniques for practical applications.

Perhaps the most intriguing prospect involves the use of the plant cells stripped of their cell walls. It was discovered that protoplasts can be made to fuse with other protoplasts and one area of work currently being pursued is the use of protoplast fusions to achieve hybrids that could not be obtained through regular plant breeding. For example, there is a "somatic or parasexual hybrid" between two species of to-

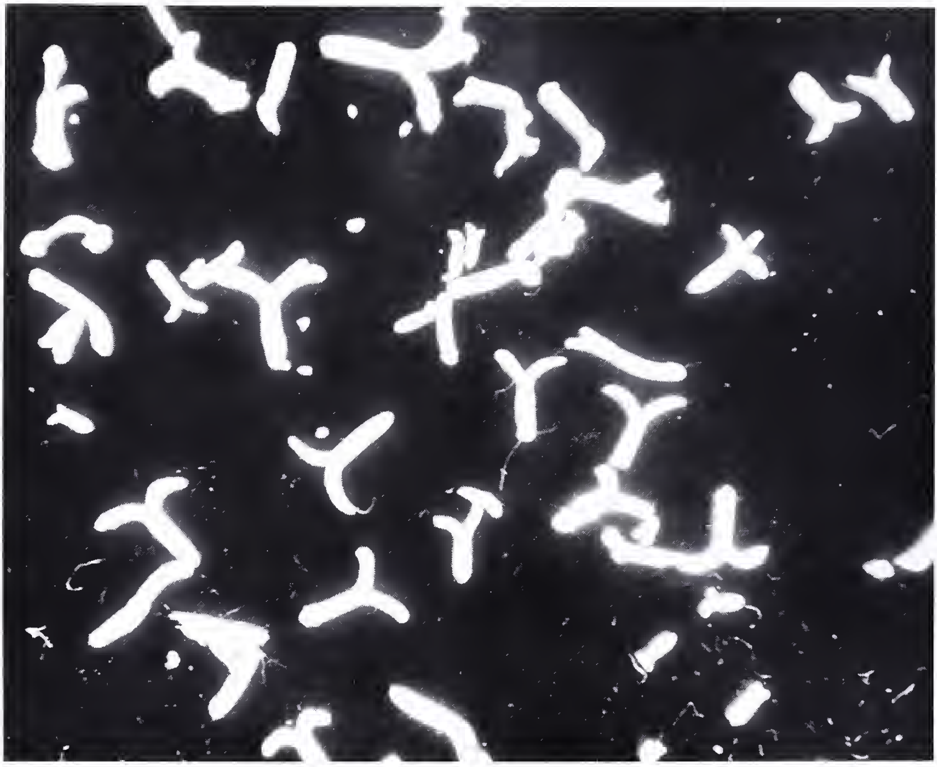


Fig. 4. Somatic embryos grown from caraway cells in culture in which their growth has been regulated. They have not germinated but remained small. At this stage, they could be readily grown into plantlets or placed into artificial seeds.

bacco that could not be made naturally. The resulting hybrid has the disease resistance of one parent and the commercially-valuable traits of the other. A second area of current research involves the use of protoplasts as the recipients of only parts of cells or genetic material, such as cloned DNA. We are now truly in the realm of genetic engineering. This is an intriguing area of current research but it may take a while for practical results to emerge. It is a complex, difficult subject best left to another article. However, the development of genetic engineering techniques and their utilization in plant improvement rests on the ability to grow cells and regenerate plants from them. This is also rapidly developing with many practical and wonderful applications right now.

Suggested Reading

Thomas and M.R. Davey. *From Single Cells to Plants.* Wykeham Publications (London) Ltd, London and New York and Springer-Verlag, New York 1975. (An easy to read presentation of the entire subject.)

J.H. Dodds and L.W. Roberts. *Experiments in Plant Tissue Culture.* New York. 1982. (An introduction to basic techniques).

D.A. Evans, W.R. Sharp, P.V. Ammirato and Y. Yamada, editors. *Handbook in Plant Cell Culture. Volume 1. Techniques for Propagation and Breeding.* Macmillan Publishing Co., New York. 1983. (A complete presentation of both basic and applied techniques. Volumes 2 and 3, due out in mid-1984, will detail the applications of these techniques to particular crop species.) ☙

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A man does not plant a tree for himself;
he plants it for posterity.
—Alexander Smith

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PLANTS & GARDENS
BROOKLYN BOTANIC GARDEN RECORD

GARDENING WITH CHILDREN

A HANDBOOK

CHILDREN'S GARDENING PROGRAMS IN
NORTH AMERICA, ENGLAND, AUSTRALIA
–HERBS, VEGETABLES, FLOWERS–
ACTIVITIES, PROGRAMS, RECIPES

Pioneer Children's Gardening at BBG
Gardening for Children with Special Needs
Children Write about Their Gardening Adventures

Vol. 40, No. 3
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PLANTS & GARDENS

BROOKLYN BOTANIC GARDEN RECORD

GARDENING WITH CHILDREN

Vol. 40 **Autumn 1984** **No. 3**

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GUEST LETTER FROM THE BROOKLYN BOTANIC GARDEN

Step One—Engage Enthusiasm

The following preface to "Children's Gardening" has been written by Doris M. Stone, recently retired Director of Education at Brooklyn Botanic Garden. She has spent the better part of her life introducing children to the wonders of the plant world.

Educated at Oxford University in England, Mrs. Stone has taught on both sides of the Atlantic. Her sojourn at BBG was in two segments, the first being from 1957 to 1967 as Plant Breeder. She tended many of the plant crosses that ultimately resulted in Magnolia 'Elizabeth'. In addition, Mrs. Stone taught classes in the Education Department for both adults and children.

The most recent segment, the past two-and-a-half years, Mrs. Stone served as Director of Education, retiring on October 31, 1984.

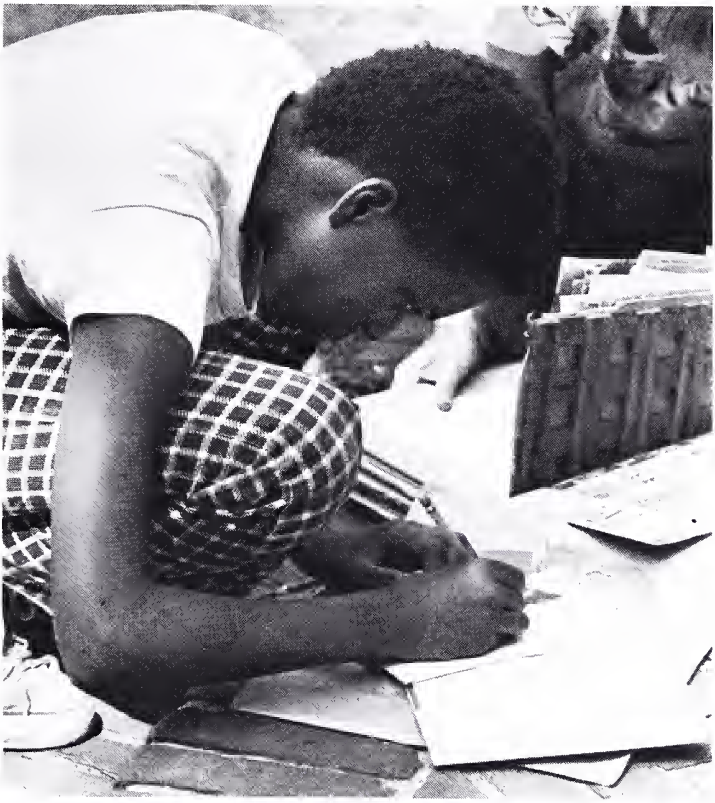
Doris Stone expresses her teaching philosophy in the following:

The teacher of biology has an advantage over the one who teaches, say, social studies or mathematics. Children are so much more interested in the living things around them than in historic battles or quadratic equations. Yet, because of our kinship to the animals, children are always more drawn to them. How then can we elicit interest in the members of that other kingdom of living things—the plants? The obvious answer is to move out of the classroom or laboratory and acquaint children with plants in their own milieu. If a child has a great deal of curiosity, a trip into a forest, through a meadow, or along a stream bank, works wonders. Lacking this basic curiosity, which verges on the scientific, children can usually be persuaded or even motivated to become plant caretakers, i.e., gardeners. And, if the crop planted is edible, so much the better—a goal has been presented and subsequently achieved. Children are so much quicker than adults to sense the "aliveness" of plants. A seedling becomes a kind of pet, which they marvel at as it develops and expands. But, unlike a real pet, they have no compunction about eating it when it matures.

Pride of ownership (or, more correctly, stewardship) is an important ingredient which we should not overlook in planning our teaching strategies. I discovered this by accident. One autumn I decided that my 10th graders should learn some ecology first hand. On the periphery of the football field each pair of students measured and staked out a square meter plot; some plots were on a bank, some in the shade of trees, and others mere bits of mown lawn. For four weeks the students studied the animals and plants—the earwigs, the grasshoppers, the sowbugs, ragweed, lady's thumb, and other weeds—in their plots. Specimens were examined under microscopes and identified, photos were taken with expensive cameras, maps were drawn and reports written. To me it was amazing that these outwardly-sophisticated students who were on their way to prestigious prep schools should have gotten so involved with "their" plots, some even visiting them in their free periods to record animal activity or changes in shading patterns. In actual fact few animals were encountered, the students were really studying plants. It was with great reluctance that in the fifth week these teenagers relinquished the stewardship of their plots to return to molecular biology—a study compulsory for the College Boards Examination.

Enthusiasm on the part of the teacher will motivate kids to study almost anything, provided that they realize that the teacher is sharing this enthusiasm with them as equals. I remember a French teacher in my childhood who was so enthusiastic about botany that she was compelled to transmit this excitement to us fourteen-year-olds every Monday morning after a weekend in the country. Returning with a bunch of wildflowers, she would place a series of jam jars filled with bluebells, cowslips, butterfly orchids and others on her desk for us urban children to inspect. For thirty minutes French verbs were forgotten while we learnt about these fascinating plants (except for one Monday when it was known that the headmistress was "on the prowl"). Once, I recall, she triumphantly brandished a bee orchid. (In those far-off days no one had thought of conservation or the possibility of endangered species—wildflowers were there simply to be picked.) Our class looked forward to these clandestine botany sessions—we urban children had been "turned on" to wild flowers (aesthetically or scientifically, it did not matter which) by this eccentric schoolmarm, crazy about the beauties of the English countryside. Her name I have now forgotten, but the effect of her enthusiasm after fifty years remains.

What I am really trying to convey with these reminiscences is that one should always keep in mind the fact that in order to "teach Johnny Latin" one must be more interested in Johnny than in Latin. Only if you first consider and care about Johnny will you encounter success. One example from an article in this handbook will suffice. The caring for Patsy and his accomplishment that Ellen Eddy Shaw unwittingly displayed in her letter (see p. 18) was the kind of concern that made her an outstanding teacher in the field of children's gardening and horticulture—a pedagogical pioneer in the early decades of this century.



William Carnahan/USDA

GARDENING WITH CHILDREN— IT'S DIFFERENT!

Victoria Jahn

Children like to plant things that are pretty, taste good, or are easy to grow. They also like the biggest, ugliest, and fastest-growing plants.

They don't like to cultivate . . . or to weed. They also don't like washing garden vegetables and tend to make mud puddles in the refrigerator.

Still, gardening with children can be enormous fun, if you are prepared.

Weeds. Be prepared for a weedy garden. You might consider various mulches to reduce the labor of pulling weeds. Grownups usually hate to weed, so why should kids love it?

Perfection. If the kids manage to create a mini-Versailles in the backyard . . . be suspicious. Most kids plant more than they can take care of, or eat. Weeds tend to grow during the height of baseball and swimming season. Try to arrange to have something like peas and radishes to harvest before the dog days of summer, just to keep them interested. Waiting to harvest is hard for the young. You adult gardeners who wait for the first tomato know what we're talking about.

Sharing. This is one of the great pleasures of gardening. Try to plant vegetables which are easily divided up, so that kids can swap their harvest. Limited-space gardeners can choose radishes, cherry tomatoes, beans, lettuce, scallions. Those with more space will find they get abundant harvests from cucumbers and squashes.

Catalogs. Seed catalogs generally begin to appear in January and provide snow-shoveling gardeners with hours of pleasant reverie. Some companies will provide school classes with multiple copies. Have kids go through the literature and make informed choices of vegetable varieties based on disease susceptibility, days to harvest, space needed, and other considerations. Kids tend to gravitate toward the exotic, so let them, up to a point. Plan for a core group of fail-safe vegetables with a few odd-balls selected to generate interest.

Tools. Avoid heavy, landscaper-sized tools; they will fast exhaust a small gardener. (Even some adults will find smaller, lighter tools preferable.) Look for iron rakes with small heads (about 9″). A small onion hoe or scuffle hoe is easier to use than the old-fashioned D-headed hoe which requires a chopping motion. The onion and scuffle hoes require a push-pull motion (almost like mopping a floor). With each motion, the blade slices weeds directly under the soil surface. Also avoid D-handled shovels, spades, and forks. Straight-handled tools adapt to a gardener's height more easily and can even be cut to fit (the end must be rounded again to fit the hand). Keeping all tools sharp and oiled also will make the work much easier.

A Child's Own Garden

Sharing a parent's garden never seems to work well no matter how well parent and child get along. A far better idea is to give children their own corner of the yard. If it's screened off from adult scrutiny, so much the better. Kids' standards of neatness and perfection hardly ever come up to adult standards. It's hard enough to get them to clean their rooms without adding another potential battleground.

The Plot. It may seem obvious, but start small. (This advice can apply to overambitious adult gardeners, as well.) Garden beds should not be wider than four feet and accessible from both sides. Young gardeners should not have to step into the plot in order to weed or cultivate. It is too easy

William Carnahan/USDA

A young BBG gardener harvests his bounty after a spring and summer in the Children's Gardening Program.

to step on a precious tomato plant while encouraging carrots to grow. A trellis or teepee of bamboo for vining crops makes the plot more noticeable and "important."

Layout. Planting in wide rows (also called double rows) and intercropping have recently gained great favor among adult vegetable gardeners because these techniques pack more plants into the plot than traditional spacing. The result is bigger harvests and fewer weeds . . . an idea kids can readily appreciate. Garden plans also should fit a family's lifestyle. Extended summer vacations away from the garden should mean planting mostly spring crops such as lettuce, radishes, beets, spinach, scallions, and peas. These can be replanted for a fall crop. Finally, plant only what everyone likes to eat. Three-week-old Swiss chard in the refrigerator is depressing.

Having Fun. This comes naturally. Kids have a great desire to explore, nurture, and learn. Encourage them to experiment. Avoid excessive meddling and they will very likely favor you with some interesting questions. They might even teach you something. Even if the first harvest is thready carrots and six snap beans, lay the praise on with a trowel. So what if Burpee's catalog says they're supposed to be prizewinners, just getting something to grow is quite a thrill.

Photos by William Carnahan/USDA

Careful preparation

Children's Gardening at BBG

Doris M. Stone

Introducing children to the marvels of plant life is one of the educational benefits of a children's garden, but it is more than education, for it can stimulate a sense of wonder and a respect for living things. A line of radish seedlings erupting out of the soil can cause city children to jump up and down with excitement—provided they were *their* seeds and *they* planted them. And what a miracle to plant a sunflower seed half as big as a dime and in a mere 80 days find in its place a gigantic plant 10 feet tall with a flowerhead as big as a dinner plate! Food for thought for both children and adults. Budding scientists may seek the answer, others may simply be satisfied contemplating the miracle.

Whether we stimulate insatiable curiosity about life, or simply instill a sense of wonder, we have conferred upon our charges something of great value which will remain with them all their lives. This, to me, a botanist, is the lasting harvest of gardening with children.

The Beginning

The Brooklyn Botanic Garden was the first major botanic garden in the world to include within its walls a teaching garden cultivated by children. Ellen Eddy Shaw, whose brainchild it was, had the foresight in 1914 to understand the marvelous educational opportunities inherent in such a project. Not only would children learn horticulture and botany by direct experience, but they would also learn to share, to respect others' rights and property, to work within a team, as well as the rewards of labor.

From 1914 to 1945 Miss Shaw, as Curator of Children's Education, was the director of the Children's Garden. The Garden was unique in that it was not just a gardening program, but it was a club—the Boys' and Girls' Club—which had its own appointed officers, regular meetings run strictly by Robert's Rules and its own selected charities (in 1919 it gave support for a French child left fatherless by WWI; in 1943 relief for war victims in China and the Soviet Union). The Club was most active in winter when gardening (at least outdoors) was at a standstill. Practice in public speaking, even for the very youngest, was considered a most important function of the club. Accounts of individual research projects had to be delivered orally.

In 1945 Frances M. Miner, who had been Miss Shaw's assistant for some years, became Curator of Instruction and Director of the Children's Garden. With few modifications, the program continued to run very much in the manner of Miss Shaw's Garden, and it continued to be one of the most successful programs of its kind. Models of the Brooklyn Children's Garden were developed in other parts of the country and abroad. Young instructors from countries as far away as India and Taiwan participated for a year or more in the program, carrying back what they had learned to their own countries.

Moving toward the Future

In 1974, when Miss Miner retired, changes began to take place. The tight structure and organization relaxed, the Boys' and Girls' Club disappeared and with it the cups, medals, silver pins, and other

A Children's Garden Instructor addresses the latest crop of young gardeners.

trophies. All of these changes were healthy and appropriate within a program that had seen little or no change in sixty years and which had been led by only two indomitable women who were born leaders. After some years of experimentation, of "throwing the baby out with the bath water" and free-wheeling, the program has now returned to the more structured form of earlier years. Some tenets of education are valid whatever the fads and fashions of the time. Once again instructors are being shown how to teach, exactly what to do at each session, and the best ways to accomplish the goals that have been set.

Under scrutiny at present are ways to encourage interested gardeners to learn more about plants on their own by individual research. A return to the silver pins and medals of former days is not an impossibility. Also under scrutiny is the possibility of a year-round program and perhaps a rebirth of a Boys' and Girls' Club geared to the social needs of the 1980s. Rebuilding on the past does not mean that we are not open to appropriate innovation. At the moment of writing the approaching Seventieth Birthday Celebration, which has prompted a reexamination of the Children's Garden archival materials, is stimulating the current Education Department to reevaluate and formulate the present goals of this unique educational program.

The Children's Garden—The Yearly Sequence

Spring Registration. Registration takes place between January and March and is open to children nine to seventeen who can attend regularly. The fee is $20 but no one is ever turned away because of inability to pay—scholarships are available, thanks to funding from several sources.

Gardening Begins Indoors. The program begins in March with three indoor sessions each two hours long. Each child is assigned to a group of 12 to 16 children of approximately the same age and taught by a staff member, assisted by a high school gardener, known as a Junior Instructor. Two children share a 4′ × 15′ plot which is designed for them by the Coordinator of the Garden, who also chooses the crops they will grow. Older children have somewhat larger plots (8′ × 15′) which they design themselves, choosing their vegetables from a list of available varieties. While the younger children learn basic gardening techniques and how to interpret their garden plans, older children choose their crops and design their gardens, as well as starting seeds in the greenhouse.

Outdoors—Spring. Planting Day is usually the last Saturday in April; children bring a picnic lunch and remain until 2 P.M. The traditional parade from the Administration Building to the Children's Garden begins at 9 A.M. Flag-bearers follow the "mascot" of the year—the smallest child—who is pushed in a wheelbarrow to the garden.

Together the partners share the work—raking the soil, measuring and labeling the rows, and then planting the seeds of cool weather crops, such as beets, spinach, carrots, and lettuce. The day, as every day, ends with the cleaning of tools, stored away by two "House People"—high school students responsible for the tool collection. (Some of the rakes date back to the first season of 1914.)

Children attend every Saturday through June. Activities during this period include weeding, mulching, cultivating, as well as planting onion sets and broccoli transplants. Some children take weeds to the "dump" or compost pile, others work on community plots, while the literary and artistic work on the Children's Garden Newspaper. In mid-May beans are sown, as well as greenhouse-raised plants, such as tomato and pepper and, for the older gardeners, okra and eggplant. Harvesting begins in late May with radishes, followed by lettuce, scallions, and broccoli.

The Summer Program. Registration for the Summer program which begins directly after the July 4th holiday takes place in June. Some of the spring gardeners return and continue with the same plot they had during the spring; others go off to camp or on vacation, leaving their plots to the incoming summer registrants. Classes are held two mornings a week. Tuesdays are devoted to gardening; some of the newcomers must be individually tutored because they are beginners. Apart from a second sowing of beans the summer gardeners have, regrettably, little to plant—they inherit an already planted and (one hopes) well-weeded garden. Fridays are devoted to classes in plant-related subjects, such as weeds, garden insects, flowers, and pollination, dyeing with plant materials, vegetable wok cookery, and drying herbs and flowers. Day trips to nature centers may also be made on Fridays.

On Thursdays in August children may voluntarily attend craft classes involving plant materials. The items made are sold at the Harvest Fair.

Sunflower Competition. In May two sun-

Careful records are kept throughout the garden year, especially at harvest time.

flower seeds are planted in each plot. By August each plant is 10–12 feet high. A competition is held with the Director of Horticulture acting as the judge to see which partners possess the tallest plant and which the largest flower head.

The Harvest Fair. The season ends with the Harvest Fair held on a Saturday in September. All the items sold have been made by the children; they include herbal vinegars and salts, dried-flower arrangements, collages, paintings, and potpourri. Home-made snacks are available—raw vegetables served with herbal dips, cakes, cookies, and cider. Children and instructors do the selling—all profits reverting to the Children's Garden Fund. During the afternoon a band plays music for square dancing.

The Children's Garden Staff. It includes BBG Staff who are college graduates with degrees in horticulture or botany. So that the groups of children can be small (12 to 16), some part-time staff are hired for Saturday mornings in spring. In the summer these are replaced by Summer Fellows (see below). *Junior Instructors* are chosen from the older gardeners; they must be 14 years old and have been in the program at least one year; many are veterans of five or more years. They receive a small stipend. Not all of them teach, two are "House People," while others do general maintenance work within the Garden. *Summer Fellows* are the recipients of fellowships awarded every summer to three or four college students who are enrolled in horticulture courses. Endowment funds are available for this purpose. The *Coordinator of the Children's Garden* runs the entire program. This person does no direct teaching. He or she, however, is responsible for training the instructors. The Coordinator reports to the Director of Education.

Stir-Frying Vegetables with Young Gardeners

Betsy Jacobs

To encourage children to take an interest in preparing their harvested vegetables, BBG began cooking classes during the summer gardening program. It has become extremely popular.

Although this program is similar to the one offered at the Royal Botanic Garden (see p. 35) there are some variations. Since this class also serves as an elementary botany lesson for the younger gardener, it begins by challenging the participants to think of the parts of plants that are edible. The object is to include roots (carrots, radishes), stems (broccoli, kohlrabi), leaves (Swiss chard, parsley, basil), flowers (broccoli, squash blossoms, nasturtiums), seeds (beans), and fruit (tomatoes, eggplant, squash, peppers).

Children are divided into teams to gather the various plant parts from their own gardens and the community plots. The bounty is then washed and some children are assigned to slice, chop, or grate. Pieces will cook better if an eye is kept on uniformity of size.

An electric wok is used because of its convenience. Oil is added once the wok is hot and then the vegetables with large pieces of stems and roots and, finally, the more delicate leaves. The stirring is done with a wooden spoon.

The feast is consumed with chopsticks. Soy sauce is an optional seasoning because the flavors of the vegetables and herbs are interesting in themselves.

The children prepare the meal from start to finish. No recipe is required and infinite variations are possible. The direct result of this activity is that many go home with their garden's bounty to cook a meal or two for their families.

BBG

Potting-up tomatoes, c. 1950

FINGERS IN THE SOIL

Initiative and responsibility grow on a half acre where 230 children till the soil.

Frances M. Miner

Be it sixty-nine radishes or thirty-four beans, the first harvest is a thrilling experience to junior horticulturists. In the Children's Garden of the Brooklyn Botanic Garden they take home far more than radishes and beans. They take home visions through new doors which have been opened to them by working with plants and soil.

One young gardener was quite disturbed when his tomatoes failed to produce fruit. The plants were healthy but lacked tomatoes until the day an instructor saw Johnny picking off the blossoms . . . why? Because he wanted tomatoes on his plants and "not these old yellow flowers." Johnny learned the hard way that a blossom is necessary to fruit production and that fruits lead to seed which in turn lead to new plants and more flowers. Johnny took home more than tomatoes.

And then there was little blond Joan who asked, "Why aren't there seeds in radishes?" That answer could be grown—a radish plant was allowed to bloom and form seed. Joan learned that the edible part of the radish is not a fruit but is a part of the root system. Then she began to notice that not only roots and fruits of plants are eaten, but also stems of asparagus, leaves of spinach, leaf stalks of celery, and the flower buds of broccoli. The radish seed Joan planted that spring sprouted far more than round, red radishes.

The Saturday morning classes which begin early in the spring, indoors and in the greenhouse, prepare each child for actual gardening. Soil is prepared, seed sown in pots, and the seedlings pricked out and planted in flats. A garden plan is laid out in chalk on the floor and each child learns how to measure rows and space the seeds of beans, carrots, and lettuce. Succession plantings are planned and many different vegetables selected—children like variety. More important, perhaps, is the choice of some fast-maturing crops such as radishes

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Reprinted from *P&G*, Summer, 1950. Miss Miner's insights and enthusiasm for children and gardening do not diminish with time.

BBG

"Homeward bound after a busy day," 1946.

and spring onions—children are impatient for results. Two months is an eternity at the age of nine. But in their own gardens where they watch vegetables grow, Jimmy and Peter and Angela learn to wait. Though not as pretty as flowers, a vegetable crop is practical and edible. Youngsters like practicality and do not have to ask, "What's it for?"

Often the idea has been expressed that every child should have a puppy. Every child should also have a garden, for only in a garden can he learn to evaluate the true importance of plant life. A puppy is a living thing, so is a plant. It is necessary to know something of both.

An 8′ × 10′ [now 4′ × 15′-*Ed.*] plot may seem small for two young gardeners, but with care and a little planning they can reap a bountiful harvest. The challenge of successfully growing beets, onions, corn, and tomatoes carries with it the deep satisfaction of individual accomplishment. This is more lasting than soup greens and salad. The ability to work hard together or alone, to respect the rights and property of others and to have a good time on the job—these too, are part of the harvest. ❦

Insect Study

Alan Gorkin

Teaching children about insects goes hand in hand with gardening. Bees pollinate, caterpillars eat leaves, cutworms decapitate seedlings. There are the "good guys" and the "bad guys."

The following list of publications has been used by the instructors at BBG. They can be used for general reference and for projects. Turn to your local library for further information.

Arnett, Ross and Jacques, Richard. *Simon and Schuster's Guide to Insects*. Simon and Schuster, 1981.

Easy-to-use guide to insects with large color plates.

Dirig, Robert. "Growing Moths." 4-H Members Guide M-6-6. Cornell University Press, 1975.

Inexpensive pamphlet with excellent illustrations and sources of insects and supplies. Describes how to raise moths.

Klass, Carolyn. "Know Your Insects." 4-H Members Guide M-6-1. Cornell University Press, 1981.

Excellent youth guide to general insect study.

Klass, Carolyn. *Some Butterflies and Moths*. Cornell University Press, 1981.

Covers common families found in N.Y. State with color photos and family descriptions.

Neidhoefer, James. "Insect Life." Merit badge pamphlet. Boy Scouts of America, North Brunswick, N.J., 1973.

Easy to read, well illustrated small pamphlet covering general aspects of insect study.

Ocone, Lynn. *The Youth Gardening Book*. Gardens for All, National Association for Gardening, 1983.

Excellent book filled with gardening related projects for kids, many insect related.

Russell, Helen Ross. *Winter Search Party: A Guide to Insects and Other Invertebrates*. Thomas Nelson, Inc., Nashville, Tenn., 1971.

Well written book with naturalist and insect related topics woven into easy-to-read chapters. Excellent bibliography and references, good for adults and children. Useful for urban audiences.

Zim, Herbert S. and Cottam, Clarence A. *Insects*. Golden Press, N.Y., 1962. ❦

A BBG LEGEND: Miss Ellen Eddy Shaw

Donald E. Moore

It is a great failing of the Brooklyn Botanic Garden, otherwise the source of every kind of information a person might need concerning plants, that it has never produced a satisfactory answer to the radish question.

Every year for seventy years, there has been a Saturday in late April when packets of seeds are placed in the hands of several hundred city children as young as nine years old. After the soil has been carefully worked in each tiny garden plot, the seeds are dropped into rows according to arrangements meticulously worked out on graph paper during classroom sessions weeks before. The first harvest comes in about six weeks. The first harvest, inevitably, is radishes.

The child, never having personally produced a miracle before, bears them home in triumph.

Then comes, for a mother, the supreme test of her nurturing ability. How do you respond to this peculiar prize without diminishing the grubby young gardener's enthusiasm and self-esteem?

Worse yet, what do you do with it?

The lettuce and tomatoes are still weeks and months away, respectively, and so you can't make a salad. A little bit may punch up a casserole, but no way can it be a main ingredient.

The child wants everyone in the family to make a meal of this first crop, which is indeed a miracle given the circumstances.

What's a mother to do?

It is estimated that each child, on a certain Saturday in June, takes home an average of 73 radishes. As this has been happening since 1914, it means that the heroic mothers of Brooklyn and other New York City boroughs have had as many as two million radishes to deal with.

It's all because a strong-minded, high-principled school teacher was brought to Brooklyn when she and the Twentieth Century were young.

It's all because of Ellen Eddy Shaw.

Miss Shaw Comes to Brooklyn

Miss Shaw was hired in 1913 by Charles Stuart Gager, BBG's first Director, the scientist-builder-genius who guided through three decades the transformation of fifty acres of ash-dump wasteland into the enchantingly beautiful garden that exists today. Among the then-revolutionary ideas of Dr. Gager, the two that made the Brooklyn institution unique were that the requirements of a systematic botanic layout could be combined with

Photos by Louis Buhle

The distribution of penny packets of seeds to school classes was once the work of youthful BBG volunteers.

A BBG terrarium absorbed the interest of children visiting from a New York City public school.

pleasing landscape design and that a scientific institution could directly inform laymen through a popular program of education.

In Ellen Eddy Shaw, Dr. Gager had the perfect partner for the latter objective.

The BBG *Record* of 1914 notes: "On May second was started the outdoor work for children at the Garden. One hundred and eighty children applied for gardens and 150 received them, leaving a waiting list of thirty names. . . . The individual garden beds, 5×7 ft. in size, are planted to vegetables, including beans, kohlrabi, onion seed, onion sets, carrots, beets, radishes, and lettuce. Flower beds were planted by the children about the boundaries of these sections. Then there are some larger sections planted to grains, peanuts, melon, corn, and other things unsuited to planting in small areas. These again are study spots, where the children learn about the growth and culture of other plants than the very few which it is possible to raise in small individual garden beds. Another area is to be planted with plant families, a few of the more common having been chosen for study. . . . Some of the older boys have sections in which they are carrying on experimental work."

What Miss Shaw later came to call "Our Pattern" was set, right at the beginning.

"Our Pattern"

Each child, however young, was to plan, plant, tend, and harvest his or her own vegetables in an individual plot (or, in most years, two "partners" were assigned to each plot). Additionally, each child was expected to help with common areas—the flower borders and beds of melons, corn and other large-area crops. In early decades, teen-agers were also expected to work elsewhere in the Botanic Garden. Those who were especially eager and qualified were encouraged to do serious research as well.

The fact that Miss Shaw had a fine ability to marshall "slave labor" has been commented on in 1984 by several good-natured correspondents. And she herself acknowledged using the technique to solve a problem in supervision brought about by the rapid growth of the program.

In a 1920 report, Miss Shaw said 320

children were selected to garden for six months, boys and girls who "must have lessons and must be cared for. How was this to work out? Our trained help was too few in number."

There were among them, she noted, some thirty boys and girls who had been at the Garden for three to five years. She put them to work:

"So each one was presented with a given number of children, according to his talents, and each was responsible for these young children, not only in garden work, but in garden behaviour, because one of the most valuable lessons taught in the garden is that of the right attitude toward our children's garden and the Botanic Garden as an institution and toward life in general. . . .

"The individual children were placed all over the garden, so that there should be no spots too weak and no situations too entertaining. It was amazing to see the amount of real, good work done by these boys and girls of approximately 15 years of age. They taught the children with great pains, and perhaps with more labor than a grown person would have given to the individual, and the children responded with perhaps greater delight to these youthful teachers than they would have to the trained teachers."

A high school senior, she said, was assigned to direct four small boys twice a week in preparing cuttings from the greenhouse collections to make rooted plants available for other children.

"His work, he distinctly understands, is

Silver pin work by young researchers in the 1920s.

to train those others into useful people who can do independent work," she wrote.

"No work is truly successful until out of it comes an independence of thought and action."

To secure maximum work and seriousness of purpose from the thousands of boys and girls who orbited about her in her 32-year career at the Garden, Miss Shaw invented an elaborate system of incentives—buttons, badges, pins, cups and, ultimately, college scholarships.

Patsy's Garden

Despite the numbers, Miss Shaw gave prodigiously to the individual child. A 1938 letter to a woman in Texas, who had asked for more detail about an anecdote Miss Shaw had mentioned in a speech, says in part:

"I think probably I was swung along a little by the fact that the speaker before me was using as one of the most important things in education, artificial stimuli such as radios and motion pictures, and I got up to say that I thought one of the most thrilling things for a child was to watch the growth of a plant from a seed . . . the joy that comes from handling life rather than sitting in a room listening to something over a mechanical device. . . .

"The story I told was this. When I first came to Brooklyn, I hoped that all the children might have gardens. In order to start, I asked teachers in two very poor sections of the city to distribute seeds. . . . One morning I received a card with the message, 'Come and see my garden—Patsy,' and an address on Myrtle Avenue, one of the poorest sections. . . . I started out this hot August day by trolley and went to the address. Sitting on the doorstep was a little red-headed, freckle-faced boy, who sprang up and said, 'Have you come to see my garden?' 'You are Patsy,' I said. He then took me through a long, dark hall down into the cellar and up into the city backyard. The windows of tenement houses looked down upon it; the ground was hard-baked. I saw no garden. Turning to Patsy, I said, 'Where is your garden?' And he said, 'Over there,' pointing to one corner of the yard, in which, as we approached, we found one bean plant growing. . . .

"A red head was poked out from a fourth-story window and a voice said, 'Ain't it fine?' (That was Patsy's mother.) 'And he had a bane on it.' 'Oh,' I said, 'did he have a bean?' Just imagine that little bit of a dwarf bean plant with one little string bean probably about the size of your finger, his own crop. Then she continued saying, 'And I bought a quart to go with it. I cooked them, and he ate his own bane.' 'Oh,' I said, 'but how did he know his own bean?' 'I tied a string through it,' she said. Imagine that family sitting around a table on a hot summer day fishing around in a dish of beans to find one little bean with a string through it. So typical of a mother to take the small endeavor of a little son and change it into something glorious. That boy went on with his garden for several years and really eventually had a very nice garden. . . . It was one of the nicest experiences I ever had."

The story illustrates the things about children and learning and teaching that Miss Shaw believed and that she wrote about in reports and essays over her years at the Garden. These are just a few of her powerful sentences that summarize her philosophy:

"A wonderful lesson is learned when it is possible for a child to pick up whatever task comes to him and be able to feel that he is going to be able to enjoy that special thing. . . . When work may be entered upon because we want to do it and when, if it is not entered upon, someone else is bound to want to do it, immediately the problem of enjoyment is solved. Psychologically, we should arrange our work so that young people are standing on tiptoe with eagerness to be a part of any given work. . . . Work planned for children should always be planned with a definite thought that it is important. We have no business to be placing before our young people any work that is not very seriously important; and there is nothing in the world more important than to learn how to live happily and wisely. . . ."

Miss Shaw retired in 1945. She went to live with her sister in the Massachusetts home where she had spent her girlhood. She died in 1960. ❦

Winter Edition

CHILDREN'S GARDEN NEWS

THE YEAR IN REVIEW

by Thomas Twente and Peter Rothenberg

The gardening year of 1982 began, as in the past, with successful indoor classes. Planting Day, April 25, was followed by periodic rain, which, as well as being a hindrance to the gardeners, was beneficial to the sprouting plants. Last spring the Children's Garden opened its gates to the press on the newly proclaimed Press Day. Following tradition, the Children's Garden also allowed the public, and especially parents of gardeners, to visit on Open House.

In the summer, besides having regular gardening in the Children's Garden, the gardening sections went on various educational trips. They went to such places as Garvies' Point, Richmond Town, and Gateway. Educational classes on such topics as weeds, herbs, annuals, and cooking, were held on Fridays. Optional craft classes were held on Thursdays to prepare goods for the approaching Harvest Fair. The Summer Gardening Program ended with a festive watermelon party, at which we had wheelbarrow and spoon and water races, Junior Instructor dunking, the watermelon hunt, and, of course, watermelon eating.

The first Children's Garden Harvest Fair was held, after much preparation, on September 25. At the Harvest Fair the winning sunflowers from the Sunflower Contest were displayed, and handcrafted items, herbs, plants, apples, and other foods were sold. Children were entertained by two clowns, and there was music and square dancing with the bluegrass band.

The Children's Garden represented the Brooklyn Botanic Garden at the Gateway Harvest Fair. Our gardeners entered many categories, such as Best Scarecrow, Flowers, and Vegetables. Many of our entrants came home with ribbons. At the New York Horticultural Society Harvest Fair we placed Second in the Grand Prize for Community Groups, and received $100, to be used on equipment for next year.

In the last gardening season we had several new staff members: Steve Scanniello, Mary Sullivan, and Doris Stone, Director of the Education Department. It was also the initial year of the Junior Instructor Program. We are looking forward to seeing all our old gardeners, as well as many new ones, in another successful year at the Brooklyn Botanic Garden Children's Garden.

By Barbara Wally

UNINVITED GUESTS IN THE CHILDREN'S GARDEN

There are two kinds of "uninvited guests". One is the weed, which can grow anywhere. Check to see if you have any weeds in your garden. Weeds are plants that don't belong in your garden. You should know what your crops look like; so you can tell the difference between your plants, and weeds. Make sure you always weed your garden.

The other kind of uninvited guest is the rock. Rocks get in the way of crops and can stop their growth. Sometimes clods of dirt can look like rocks. To see if it is a rock, gently hit it with a trowel,or a hand cultivator. If it breaks into pieces, it is a clod of dirt , and you should make sure it's all crumbled up. If it makes a little banging sound,it is a rock and you should get it out of your garden,,and into they rock box!

Also, paper , candy wrappers ,sticks, glass, and old garden markers from last year , should t ake a trip out of your garden and into the garbage. Be sure not to mistake plants for weeds. Keep worms and ladybugs in your garden.

This is an article about a weed which has made itself quite well known in the Childrens Garden.

Galinsoga

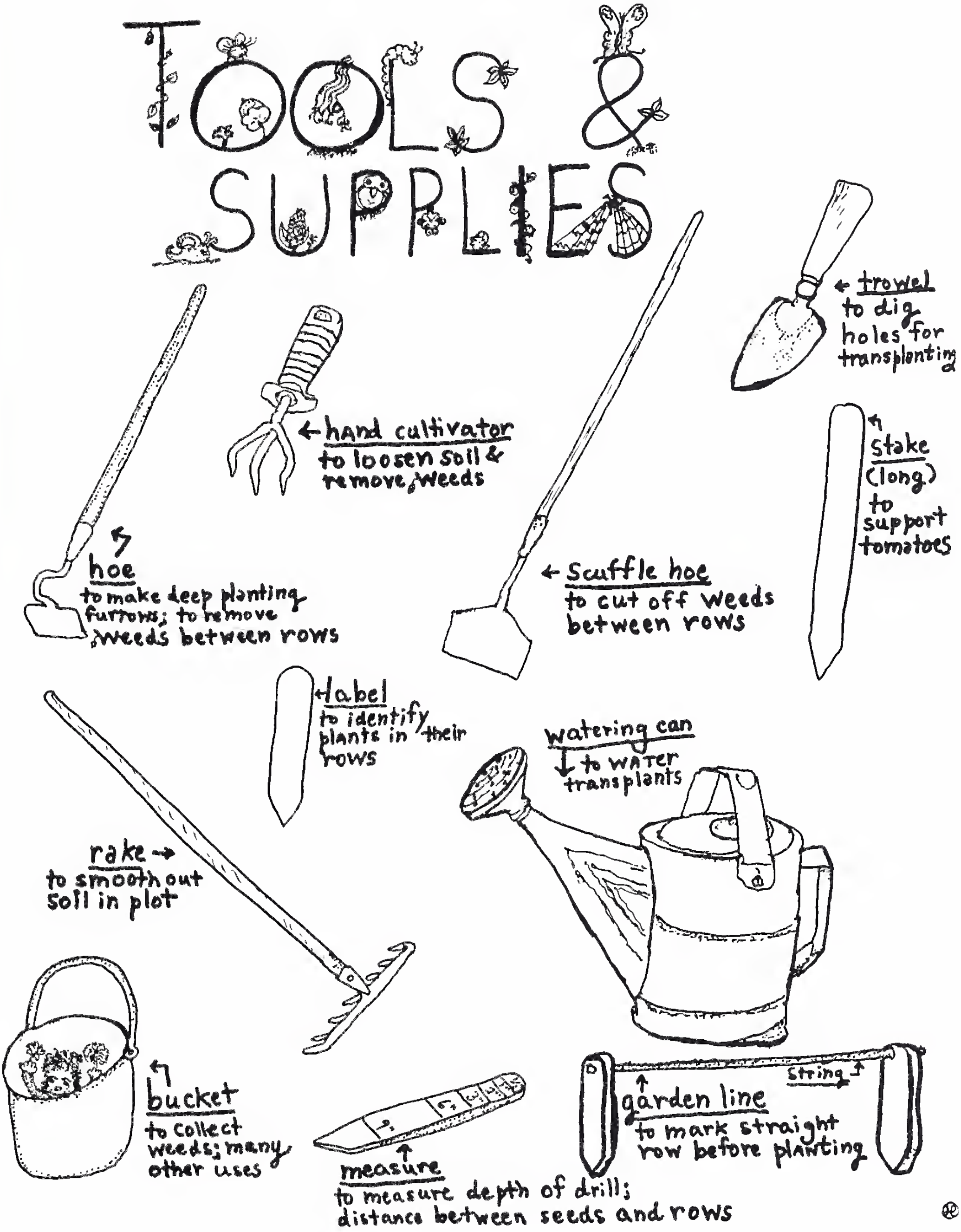
Though common in gardens and elsewhere, galinsoga does not have a common name. Its scientific name honors a Spanish botanist. This rather unattractive annual of the daisy family usually grows to be about one foot high. Galinsoga has opposite oval green leaves. The white and yellow flowers are small and delicate.

There are six known species of galinsoga that are native to tropical America. Four of these are found in the U.S.

Although found in small, as well as large gardens, galinsoga is rarely abundant enough to be a serious threat to crops. Though it tends to grow in many unwanted places.

By Alexander Edmonds

TOOLS & SUPPLIES


trowel
to dig holes for transplanting
hand cultivator
to loosen soil & remove weeds
stake (long)
to support tomatoes
hoe
to make deep planting furrows; to remove weeds between rows
Scuffle hoe
to cut off weeds between rows
label
to identify their plants in rows
watering can
to water transplants
rake
to smooth out soil in plot
bucket
to collect weeds; many other uses
measure
to measure depth of drill; distance between seeds and rows
garden line
to mark straight row before planting
String

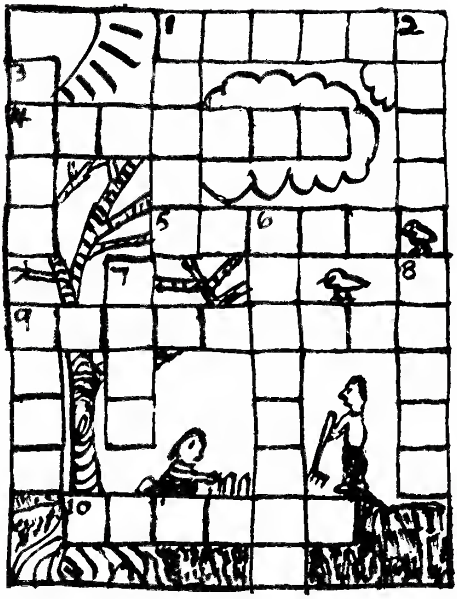
CROSSWORD by Anita Jacobs

Across

1. The Children's Garden house says: "He is happiest who hath power to gather wisdom from a ______."
4. Plants that live for only one year are called ______.
5. A potato is *not* a root; it is a ______.
9. A zinnia is in the ______ family.
10. A German car is nicknamed for this hardshelled insect.

Down

1. A cucumber is what part of a plant?
2. The fence opposite the euonymus hedge in the CG is overgrown with this flower.
3. A tool used to smooth out soil.
6. A vegetable that must be picked before its head turns yellow.
7. An early spring flower: ______ drop
8. Shakespeare: "These ______ shall be my books."
9. The mulch put on the field is called ______ hay.



Sanitary Engineers for Your Garden

By Kelly Wiggins

Worms are good for your garden, which many gardeners all ready know. But do they know that they are also good for getting rid of scraps in the kitchen?

A well known system of getting rid of kitchen scraps may sound weird; but it's a system many people use. There is a very good and useful way of getting rid of scraps in your kitchen. First you start with a two by two foot box. Then you get one half of a pound of garbage. Then you use a 1000 of your garbagemen which can be raised in your basement. Please don't get the wrong idea, garbagemen are really worms. The worms compost the scraps that are put in the box. The worms break the compost down to fine potting soil to be used in your garden.

The Clouds in the Sky

By Susanna Schroeder

All the clouds fly in the sky
To make such beutiful shapes,
But oh, there was never a shape so lovely
As the cloud itself.
So fluffy as the dandelions
After they're gray with age,
It woudn't be there.
If you shouldn't feel it when you've got the chance,
It would stay free and beautiful
For eternity.

Salt Hay

By Lában Cabrera

Why do we use it? Salt hay is spread on the paths and between the plots, so that sun can not reach the soil. If the sun can not reach the soil, no weeds can grow in the paths. Another reason for salt hay is that weeds trying to grow wont be able to get through it. Thus they will not spread into your garden. In some places were the salt hay is not spread, or is spread to thinly weeds can grow and spread into your garden. So careful attention must be paid, so that the hay is spread equaly.

There is also something else that we use, it is called compost. Compost is made from decomposed leaves. Compost is spread inside the garden itself. It will eventualy get mixed in with the dirt,, and produce a rich and more healthier soil.

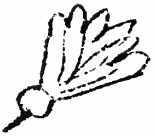
Fried Squash Blossoms

Anita Jacobs

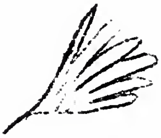
You may have wandered into the Children's Garden House on a Friday, attracted by the tempting smell of fried food. What was it? Well, one of the programs held on Fridays, was a class on cooking with vegetables. Participants of the class made fried squash blossoms, which are the orange flowers of the zucchini plant, fried in crispy batter.

Due to popular demand, I am going to reproduce the recipe for anyone who did not get a chance to take the class, or who lost the recipe.

Before you make Fried Squash Blossoms, there is one thing you have to know. In zucchini plants, some of the flowers are females, and some are males. The female flowers produce the fruit (zucchini), so you wouldn't want to pick them. The male flowers live just to pollinate the female flowers, and then they die without producing any fruit. The female has a small bulge at the base of the flower. The male does not.



female



male

Remember, when making Fried Squash Blossoms, pick only the male blossoms.

FRIED SQUASH BLOSSOMS

(Children can make this recipe themselves)

24	blossoms from zucchini or summer squash
3	eggs
½	teaspoon salt
½	cup flour
½	teaspoon baking powder
1	Tablespoon chopped parsley
1	Tablespoon grated parmesan cheese

1. Wash and dry squash blossoms, if necessary.
2. Beat together lightly: eggs, salt, flour, and baking powder.
   Add parsley and cheese. If batter is too thick, add some water.
3. Heat oil to about 350°, ½ inch deep.
4. Dip blossoms in batter and fry until golden.
5. Drain well on paper towels.

H. Mageau

The Herb Garden at "Branching Out"

HERBS: A SENSORY APPROACH TO GARDENING WITH CHILDREN

Helen E. Mageau

Herbs are such an integral part of the culinary, medicinal, and aesthetic history of man that a garden of them never fails to attract attention. The qualities that caused them to be separated out from other plants still appeal as strongly today as they did a millennium ago. For children, no matter how young, this appeal forms the basis for a wonderful introduction to the pleasures of plants and gardening. The scent of mint, the texture of lamb's ears, and the fragrance of lemon verbena delight children. Herbs such as oregano, mint, and basil have food associations which stimulate an equally positive response. An herb garden arouses curiosity and interest—both necessary ingredients in any learning situation.

At "Branching Out!", a youth gardening program conducted by the Morris County Park Commission and the Friends of the Frelinghuysen Arboretum in Morristown, New Jersey, the herb garden is planted with a selection of perennial herbs chosen for their usefulness in plant lessons and craft projects. A few simply have interesting histories or uses. Some semi-wildings such as chamomile pop up at random each spring. The selection of annual herbs varies from year to year. We try to balance the collection to include culinary, medicinal, and fragrant herbs. Our herb garden is not large, measuring only 20′ × 4′ but is big enough to supply most of our needs. Lavender forms the border and a curved X through the middle while other herbs fill the spaces in between. The overall effect is of a modified knot garden.

There are fifty gardeners between the ages of 8 and 13 in "Branching Out!". They plant and tend standard vegetable crops and annual flowers on their 5′ × 21′ plots. A few of the most popular herbs such as parsley, lemon balm, and basil are also part of their planting plan. The ability of our herb garden to produce enough of these has been outdistanced by demand.

Summer Herb Experiences

During the spring months the program concentrates on learning to plant and care for the crops planted on the individual plots, but in July, with the vegetables and annuals growing well, the herb garden comes into its own as the focal point for lessons in botany, cooking, folklore, and crafts with our newest gardeners beginning with the basics. As it is dissected the function of each part of the plant is discussed. Mint is an ideal herb to use for this purpose because it tends to be an agressive grower, so plants pulled out to illustrate the lesson barely dent the crop. The leaves are saved for the follow-up activity of making candied mint leaves. Another no-cook project that introduces chives, thyme, and rosemary presents more of a challenge. Because many children are reluctant to sample unfamiliar flavors, we begin with chives and then move on to the more exotic thyme and rosemary. The class participants cut, wash, and chop about one teaspoon of each herb to blend into whipped cream cheese or butter. Each mix is left to absorb the herb flavor and is then spread on bread or crackers. Although no child is pressured, most will try each flavor. Their response is often surprisingly enthusiastic. Even doubtful nibblers decide they like one of the three. If a stove is available, the buttered bread can be made into croutons by toasting in the oven. Cooking projects such as these are a good introduction to culinary herbs.

Since many crafts done during the summer sessions require dried herbs, early in July lessons are taught on how to cut, bundle, and hang such herbs as tansy, wormwood, and sage. Four bamboo poles are suspended horizontally from the ceiling to make a drying frame and the herb bundles are tied to the poles and labeled. Placed under the poles are two old screen doors elevated from the floor on bricks for the smaller herbs such as thyme to be spread out to dry. We also use a small dehydrator to speed up drying in damp weather and to process the large quantities of lavender and rose petals we use for making potpourri and sachets later in the season. The mixed fragrances of drying herbs fill our work area from July through mid-August, a sensory experience in itself.

Crafts

Fresh herbs are also used in some craft projects. Lavender is easy to harvest and use and is one of the most versatile. One favorite project is making lavender "bottle" sachets from the flower stalks. The stalks are bent so that the flower heads are encased in a cage of stems which is then woven through with ribbon. Because lavender can be a temperamental grower and sometimes suffers winter damage, ours is protected during the winter months by a covering of evergreen boughs. In early April it is uncovered, cut back, and fertilized to ensure vigorous growth.

It is satisfying to see children go to the herb garden on their own just to touch and sniff their favorites. Some of the most popular are lemon balm, lamb's ears, and scented geraniums, although a few less-common herbs such as costmary never fail to attract attention once they have been introduced. Costmary is also known as Bible-leaf from the custom of using it as an aromatic bookmark. It has a sweet-spicy scent which our gardeners have described as "gumdrops." We hang it to dry and incorporate it into potpourri. While costmary is a tall but unassuming herb that doesn't attract attention until it is pointed out, lamb's ears need no such introduction. Its thick, fuzzy leaves invite touching and discussion about the uses of lamb's ears often ends with the suggestion that it might be nature's cotton ball. Another herb, which tends to be a weed but never fails to invoke delight, is chamomile. For young children 5 to 8, a reading of Peter Rabbit and a sip of chamomile tea infuses the story with a new dimension.

Our young gardeners enjoy the herb lore passed along in more formal sessions or informally during weeding and cultivating. Medicinal uses for herbs are fascinating in a world of bottled and packaged cures. The herb garden is a rich source of material to inspire curiosity about man's use of plants.

Choosing and Growing

When choosing herbs for a gardening project keep in mind how much you will need for each project. If it is just touch, sniff, and taste, a wide range of small plantings will provide the most variety. If craft projects are to be included, grow enough of the herb to supply your needs. It is easy to underestimate, so be generous in your planning. In any event the selection of herbs will be based on the space available in which to grow them. A good basic collection for any group would include thyme, sage, lemon balm, rosemary, chives, lavender, basil, oregano, and mint. Another factor in choosing might be the ethnic mix of the program participants. The choice of herbs to grow is as individual as each gardening program.

One of the nicest things about herbs is that they are adaptable to a variety of growing sites. An herb garden can be a large collection planted in a traditional bed, or grown in containers outside, or grown in pots on a windowsill. Herbs grown indoors on a sunny windowsill will not have the vigor or the intense flavor and scent of those grown outside but they do well enough to supply material for small herb projects. Plant lights will improve vigor and produce a healthier crop. Herbs in containers are another alternative to an in-ground site. Window boxes, large plastic pots, or anything with drainage holes and large enough to hold at least two quarts of soil are suitable. One of the advantages of containerized plants is that they can be moved into or out of the sun as necessary. Planted in a good man-made potting soil, fertilized and watered regularly, herbs in containers will grow as well if not better than in average garden soil.

Herbs require full or at least half-day sun. Contrary to common beliefs, they do not prefer poor soil but grow best where soil and drainage are good. If the soil is less than ideal, a raised bed of improved soil is the best solution. Information on herb care and culture can be found easily in the many fine herb manuals now in print.

We live in a society where many people experience the natural world second hand from television. Flavors and fragrances come in bottles and aerosol cans. Urban and suburban children alike are often strangers to the plants, soil, and animal life that make a garden. Using herbs along with vegetables and flowers or by themselves can be a most effective way of getting children truly involved with plants and gardening by awakening a sensory appreciation for the plant world. Herbs can begin a discovery process by training the senses of young people to be alert to new scent, texture, and taste experiences. Growing a variety of herbs in addition to standard crops can add a new dimension to any gardening program. Herbs are easy to grow and offer so many possibilities to expand a child's knowledge of plants and gardening.

Holly H Shimizu

The author teaching in the National Herb Garden

A HERB WORKSHOP FOR CHILDREN

Holly H. Shimizu

One of the senses which children seem to enjoy most in an herb garden is that of smell (see p. 25). Sniff the leaves of mint and all kinds of associations will come to mind, or the leaves of lemon verbena, which will make your mouth water with its strong lemon fragrance. Herbs and children blend well together because there are so many connections children can make. In addition, it is exciting for them to use different senses, particularly smell, since it is so underused.

In our herb workshops for children in The National Herb Garden (Washington, D.C.) we try to get the children, ages 10–14, to learn to identify herbs, and to become familiar with some of their uses. In the morning we go through the garden collecting characteristic herbs recognized for their flavor, fragrance, texture, or visual appearance. After gathering, they are placed in containers with water and labeled with their common names and their meaning in the language of flowers.

Using the Herbs

As the workshop begins we like to see how the children perceive herbs, usually as some sort of flavoring used in cooking. Expanding on this, we talk about the other uses such as in potpourri. We have set up a table with individual potpourri ingredients as well as a sample of the finished product. As a first project, the children start with a sheet of several potpourri recipes and hints. They begin to think of how they want their potpourri to smell. Each ingredient is labeled and it is separated by its category: bases, fixatives, modifiers, and top mixes. Mixing fragrances allows for a sense of creativity, which is always a pleasure to children.

Next, we move on to the fresh cut herbs for making our tussie-mussies or herbal bouquets. We go through each of the herbs to become familiar with its smell by crushing the leaves and talk about its meaning. After deciding who will receive this wonderful herbal bouquet we begin to assemble the herbs. Each child is equipped with a tussie-mussie holder (available from a florist supply shop), a note pad, and a rubber band to hold the bouquet together. At first, it is hard to get the bouquet to look just right, so with the help of our assistants we encourage several efforts until the tussie-mussie is ready for final wrapping. Once placed in the tussie-mussie holder, the florist tape is wrapped around the bottom and the bouquet is sprayed with a fine mist of water.

Through these workshops, children gain inspiration and insight into the world of herbs. These are the kinds of experiences which are remembered—they are unique, they are fun, and they have a special meaning.

From the National Herb Garden

Blending Fragrant Herbs

Fragrant herbs have traveled throughout the world. Indeed, many of the plants have come a long way to reach our gardens. Plants valued for their fragrance have been treasured not only for the pleasure they give, but also as a necessity to mask bad odors and spoiled food. They have been used in ancient rituals and as offerings of worship. Apothecaries have relied on them to use in love potions and to slow advancing age. Rosemary and rue were carried to ward off the plague, southernwood was strewn on the floor to deter fleas and lice, while sage and eucalyptus were burned to disinfect sick rooms.

Using our sense of smell gives us a very special feeling. The actual effects that it has on the mind and emotions is not well understood. It is believed that incoming odors are screened by the nervous system centers and cause a reaction either to repel or to attract. Certain animals have a highly developed sense of smell, often lured by flowers or possible mates.

Fragrances affect different people in different ways. Therefore, the art of blending fragrances is a rather personal one, and the rule to follow is "whatever pleases you is right." A potpourri is made from fragrant dried petals and aromatics. Flower petals and plant parts are blended with fixatives, which absorb the oils and release them slowly, and then the essential oils are added.

There are two methods for making potpourri: moist or dry. Here we are considering only the dry method because it is the simpler of the two.

Some Ideas for Potpourri

Bases. Rose petals and buds, lavender flowers, marigold petals (or other fragrant flowers), rose-geranium leaves, sandalwood, cedar wood, mints (especially orange or *eau de cologne*), southernwood, bay leaves.

Fixatives. Gum benzoin, gum myrrh, gum storax, frankincense, false calamus root (*Iris pseudacorus*), vetiver root, orris root (some people are allergic to this), patchouli leaves, musk (synthetic or musk oil perfume), vanilla bean, tonka bean, vanillin or vanilla extract, oak moss, musk seed, sweet woodruff, santolina flowers.

Modifers. Scented geraniums, citrus peels (lemon, orange, lime, tangerine, grapefruit), mints (peppermint, spearmint, orange, *eau de cologne*), lemon wormwood, sweet wormwood, southernwood, costmary, spices (cloves, cinnamon, nutmeg, mace, allspice), lemon verbena, lemon balm, lemon grass, anise, fennel, basil, marjoram, thyme, angelica seed, rosemary, sage, pineapple sage.

Top notes. Floral oils (rose, neroli, jasmine, lilac, gardenia, lavender). Citrus oil or extracts (lemon, orange, lime). Mint oils or extracts (peppermint or spearmint). Fruit-flavored oils or extracts (raspberry, strawberry, pineapple). Vanilla extract. Spice oils (clove, cinnamon, sandalwood).

Potpourri composition.

1. Base	Bulk of potpourri	50–75%
2. Fixative	Helps hold odor	10–20%
3. Modifier	To change base (except to rose you might add spice or lemon)	5–20%
4. Top note	First sensation	1–5%

Recipes

Easy Rose Potpourri

3 cups dried rosebuds and petals
½ teaspoon dry mint leaves
½ teaspoon coarse ground cloves
½ teaspoon coarse ground cinnamon
½ teaspoon coarse ground allspice
1½ teaspoons ground orris root or gum benzoin
3 drops oil of roses

Combine roses, mint and spices in a bowl. Mix in orris root powder and oil of roses. Seal tightly and set to cure in a warm, dry, dark place for six weeks. Shake container gently every day. To use, transfer to a container with a lid.

Rose Bowl

8 cups dried rose petals
4–6 cups dried lavender flowers
⅔ cups orris root powder or gum benzoin powder
4 tablespoons coarse ground allspice
¼ cup coarse ground cloves
4 tonka beans—coarse ground or chopped
4 drops oil of roses
2 drops oil of lavender

Combine all dry ingredients. Add oils a drop at a time, mixing as you do. Seal jar and cure for six weeks in a dry, dark, warm place. Shake daily.

Marigold and mint potpourri

½ cup dry thyme
⅔ cup dry peppermint leaves
⅓ cup dry basil leaves
½ cup dry marigold *(Tagetes)* flowers
2 drops of oil of peppermint

Crush herbs lightly and mix. Add marigold flowers and mix oil of peppermint. Seal the jar and set in a dry, dark, warm place for six weeks. Shake the container daily.

American Indian incense

Cedar leaves
Cedar bark, chipped
Lavender buds
Dried juniper berries
Elderberry flowers

Carnation potpourri

Carnation petals (without calyces)
Rose petals; Rosemary
Myrtle leaves, lemon balm, Clevelandi sage
Allspice; mustard seed
Tonka beans
Carnation oil

Lavender Potpourri

English lavender buds
Dwarf blue lavender (Hidcote or Munstead)
Sea lavender (*Limonium*) flowers
Orris powder

Sources of Supplies for Potpourri

Aphrodisia
282 Bleecker Street
New York, New York 10014

Caswell-Massey Co., Ltd.
111 Eighth Ave.
New York, New York 10011

Faith Mountain Herbs
P.O. Box 199
Sperryville, Virginia 22740

Indiana Botanic Gardens
P.O. Box 5
Hammond, Indiana 46325

Smile Herb Shop
4908 Berwyn Road
College Park, Maryland 20740

The Herb Cottage
Washington Cathedral
Washington, D.C.

What Is a Tussie-Mussie?

The tussie-mussie is a delicate, tight little bouquet of aromatic herb leaves and flowers arranged in a doily and tied with a ribbon. During the 17th century, in place of the doilies, very delicate filigreed holders were used.

Tussie-mussies are a part of the English tradition. They have been used in celebrations, ceremonies, weddings, and coronations. Indeed, no less a lady than Queen Elizabeth II was handed a tussie-mussie as she entered Westminster Abbey for her coronation in 1952. In England today judges of the Old Bailey, Britain's highest criminal court, still carry tussie-mussies into the courtroom six times a year as a gesture of tradition.

In the long, long ago when plagues and fevers troubled the land, tussie-mussies were held to ward off noxious smells and illness-bearing aromas of all kinds. Even in 18th century America, a well-bred girl would not be in public without a tussie-mussie; it helped her endure the smells caused by lack of sanitation in the streets and buildings as well as assuring her of personal daintiness and freshness.

Tussie-mussies are truly nosegays with a message. Each herb has a symbolic meaning, and you may choose the ones that convey your sentiments to the recipient. Ideally, a rosebud is used for the central flower, as it represents love. Failing to have a rose on hand, three to five lavender stems tied together may be substituted. Of course the final decision belongs to the individual. The tussie-mussie has something of the refined artistry of a miniature painting, and every sprig, leaf, and flower count.

When presenting a Tussie-Mussie, part of the pleasure is writing the significance or meaning of the herbs on the gift card. To plan your Tussie-Mussie, see below.

Some Herbs and Their Symbolism

COMMON NAME	BOTANICAL NAME	SYMBOLISM
Balm, lemon (sweet balm)	*Melissa officinalis*	Sympathy
Bay laurel (sweet bay)	*Laurus nobilis*	Protection from evil
Borage	*Borago officinalis*	Courage
Burnet (salad)	*Sanguisorba minor*	Gives one a merry heart
Calendula (pot marigold)	*Calendula officinalis*	Happiness and sunshine
Chamomile, Roman Chamomile, German	*Anthemis nobilis* *Matricaria chamomilla*	Patience, fortitude, energy in adversity
Daisy	*Chrysanthemum leucanthemum*	Purity in thought, loyal love and innocence
Dandelion	*Taraxacum officinale*	Absurdity
Dill	*Anethum graveolens*	To lull or soothe; hinders witches of their wills
Hawthorn	*Crataegus laevigata*	Emblem of hope
Heartsease (viola or Johnny-jump-up)	*Viola tricolor*	Remembrance of things past, happiness, seeds symbolize the Trinity

Symbolism of Herbs, *continued*

Common Name	Botanical Name	Symbolism
Heliotrope	*Heliotropium peruvianum (Heliotropium aborescens)*	Eternal love and admiration
Lavender	*Lavandula officinalis* or *Lavandula stoechas*	Luck, purity, sweetness virtue, undying love and cleanliness
Lily-of-the-valley	*Convallaria majalis*	Purity
Marjoram	*Origanum majorana*	Symbol of honor, gift of banishing sadness, meaning youthfulness, happiness, courtesy, maidenly innocence
Mints	*Mentha,* all species	Wisdom, cheerfulness, hospitality, virtue
Myrtle	*Myrtus communis*	Love, mirth, joy, emblem of marriage
Pennyroyal	*Mentha pulegium*	To be worn on the head to prevent giddiness
Rose	*Rosa* spp.	
White		Charm, innocenee
Red		Love and desire
Rose geranium	*Pelargonium graveolens*	Preference
Rosemary	*Rosmarinus officinalis*	Memory, remembrance, devotion, fidelity, loyalty, constancy and enduring love
Sage	*Salvia officinalis*	Wisdom, esteem, insures domestic virtues, good health and the serenity of long years
Strawflowers	*Helichrysum bracteatum*	Attachment and constancy
Sweet woodruff	*Asperula odorata*	A new life
Tansy	*Tanacetum vulgare*	Immortality and healing of wounds
Tarragon (little dragon)	*Artemisia dracunculus*	Cure for bites of beasts, especially dragons!
Thyme, common	*Thymus vulgaris*	Courage, bravery, strength and activity
Vervain (Herbe Sacrée) also called Herb of Grace	*Verbena officinale*	Enchantment; code words: "you have bewitched me"
Violet	*Viola odorata*	Modesty, simplicity; code words: "I return your love," has long been a symbol of love in all languages
Yarrow	*Achillea millefolium*	Dreams of loved one

Note: For a more complete list of Tussie-Mussie ingredients and their significance, write to the Editor, *P&G,* Brooklyn Botanic Garden, 1000 Washington Ave., Brooklyn, N.Y. 11225. ❦

Careful maintenance

Photos from Chicago Botanic Garden

Children's Gardening at Chicago Botanic Garden

Linda Lutz

Many of the children's vegetable gardening programs are similar to the BBG model. There are variations, however.

The Chicago Botanic Garden has eleven years of experience in teaching gardening each year to 160 inner-city children. Because this Garden is in a suburban location, the children go there by bus. They come from nine different after-school programs and one school program. The age range is eight to twelve years.

The student gardeners are divided into three sessions of approximately fifty-five

A young gardener and volunteer harvest the hard-won kohlrabi.

Packing up a proud harvest to take home to share.

Learning to cage tomatoes to increase the eventual yield.

children. Each class lasts two hours. The group is divided into pairs and each pair works a 14′ × 15′ plot. The partners work together under the guidance of a Garden volunteer. There are more than eighty volunteers who work with the children and assist in evaluating the program. In other respects the program is similar to Brooklyn Botanic Garden's model.

An ardent Children's Vegetable Garden volunteer captures the essence of the fourteen-week program by saying: "There's nothing better than getting outside in the fresh air, the sunshine—working with people down on your knees in the dirt together to produce a miracle." ❦

First things first

Photos from the Royal Botanical Gardens, Hamilton, Ontario

YOUNG GARDENERS IN ONTARIO

Brian Holley

The first few weeks of a Children's Gardening Program are a frenzy of activity—preparing the soil, planting, weeding, and thinning. Everyone is busy. Good-natured complaints about the tenacity of weeds, and the voracious appetite of rabbits fill the air and add to the camaraderie. But soon the pace slows, routine sets in, and the enthusiasm of spring can turn into the boredom of summer.

Maintaining enthusiasm during the dog days of summer requires developing new activities. Every garden contains an abundance of raw materials. There are cucumbers to pickle, herbs to dry, flowers to press and lots of vegetables to taste. Every gardener has a wealth of information to share about cooking, propagation, flower arranging, crafts and many other activities. The way that the activities are developed can vary from a well-planned series on herb uses or a spontaneous Tomato Taste Test to a rainy-day session on terrarium construction. House plant propagation programs are effective as long term projects, especially if a variety of plants and methods are used. Another way of approaching programming is to set a goal such as a group trip. Have a series of classes to develop materials for sale, such as potpourris, pickles, jams, or pressed flower note paper. The group also could be involved in circulating flyers about the sale, manning the booths and providing tours of the garden.

Projects such as these have been part of the Children's Garden at the Royal Botanical Garden in Hamilton, Ontario, for several years. The proceeds from the sale are usually used to purchase books for the library as well as provide a trip to Dundurn Castle, a local historical site. At Dundurn Castle, the children use the brick ovens to bake pumpkin bread and the fireplace to cook plum jam, as well as touring the building and gardens to see how early settlers used plants.

The sale is held every August as part of the Open House. A vegetable auction, a judged vegetable and flower show, presentation of certificates to Junior Gardeners, and a corn roast are also part of the Open House. In addition, prizes supplied by a local seed house and garden club are presented to young gardeners in a variety of classes.

Favorite Activities

Wacky Wokking

Objective:

to develop knowledge of vegetable preparation and cooking.

Time period: 1 hour.

Required:

1 Wacky Wokker. Should be able to wield a spatula like a Samurai and chopsticks like Charlie Chan.
1 or 2 woks. (Usually can be borrowed or retrieved from the attic)
2 spatulas per wok
2–3 tbsp. vegetable oil per wok
Soy sauce
Sprouts (started the week before)
Vegetables (whatever the garden has to offer)
Ginger root, 1 heaping teaspoon chopped very fine
2 cups Chinese noodles
1 cup peanuts or almonds, if desired
Paper plates
Chopsticks

Method:

1. The wokker divides the group into collectors, washers, cutters, and stirrers.
2. The collectors are given a list of vegetables in the order that they will be needed.
3. The washers scrub the vegetables.
4. The cutters slice the vegetables. It may be preferable to grate hard vegetables such as carrots.
5. The wokker heats the oil, adds ginger, onions, and the hard textured sliced vegetables. After they have cooked for a few minutes, add softer vegetables such as broccoli, and finally leafy vegetables such as chard. Stir constantly. Add soy sauce to taste.
6. When cooked, top with nuts and Chinese noodles, and serve.

Terraria

The making of terraria is an excellent project, as it can be adapted to both the skill level of the participants and the available materials.

Spice bottles (or baby food jars) with 1 cm of moist sand in the bottom can be planted with a single tiny cutting of English ivy. This terrarium requires very little preparation, few materials, and a low skill level. On the other hand, a narrow necked wine bottle requires a great deal of dexterity and special tools. The following is a good beginners' project.

Objective:

to develop understanding of vegetative propagation techniques and terrarium construction.

Materials:

Large (128 oz) pickle bottles—available from fast food outlets
Peat and perlite mixture (or other

Making fruit-and-vegetable fantasies stretch a young gardener's imagination.

The first step toward the annual Harvest Sale can include making plum jam.

suitable rooting medium), 2 cups each
Slow-release fertilizer, 1 pinch each
Horticultural charcoal, 1 teaspoon each
Old nylon hose
Haydite or fine washed gravel, 1 cup each
Cuttings or small plants—small leaf pileas, dwarf palms, miniature ferns, strawberry begonia (*Saxifraga* sp.), miniature peperomias, nerve plant (*Fittonia* sp.), are some possibilities, but don't be afraid to try others. Generally, the plants grow too quickly, but they can be pruned.
Bark chips, marbles, small figurines if desired.

Method:

1. Collect and wash jars
2. Gently place Haydite or gravel in the bottom of the jar. It should be about 1 cm (⅜″) deep.
3. Cut the nylons into circles the same diameter as the jar and place over the gravel as a soil baffle.
4. Mix the planting medium with charcoal and fertilizer. Lightly moisten the mixture.

5. Put the mixture into the jars to a depth of about 4 cm (1½″). Create some undulations in the surface to resemble a landscape.
6. Place a single tall (about 12 cm or 4½″) and two lower plants or cuttings into the soil. Rooting hormone is not usually required. Be careful not to overcrowd. Then place figurines or bark chips to create a landscape effect. Put the top on.
7. The terraria are then complete and simply require placing away from direct light. If the condensation on the sides of the bottle is too heavy, open the top for a day. If there is no condensation at any time, water with a basting syringe, salt shaker, or mister. Prune with nail scissors as required.
8. The terrarium is a closed system in which the high humidity required for rooting cuttings is maintained. As well as stem and leaf cuttings, offsets root well in this situation.

The Great Tomato Taste Test

The blindfold taste test has become a popular advertizing technique, and it works well in the garden with all sorts of fruits and vegetables. For some reason, being blindfolded is also inherently fun for kids. In addition to comparing the tastes of the various tomatoes, the growth habit, vitality, and production can also be noted. The resulting information may decide the varieties to be grown the following year.

Bubble Gum Tea

A herb garden contains so many textures, smells, and tastes that it quickly becomes a favorite part of a garden for children. The ancient uses, myths and legends of herbs are fascinating to children and help to make the plant world a more mysterious and exciting place. As well, a small herb garden can provide materials for a great variety of projects and studies. The simplest is bubble gum tea.

Bubble gum tea starts off with a touch, taste, and smell tour of the herb garden. Suitable leaves are then collected for making teas.

Objective:
to provide an introduction to herb usage and history.

Materials:
Tea pots, at least 3
Styrofoam cups. (After use, recycle for planting rooted cuttings.)
Hot water

Method:
1. Harvest top leaves of peppermint, spearmint, and bergamot
2. Place 1 handful in tea pot and cover with boiling water
3. Allow to steep until desired strength is achieved
4. Pour small amount into each cup and taste
5. Each of these herbs has a variety of uses, both present and historical. Bergamot (*Monarda fistulosa, M. didyma*) was used by the colonists as a substitute for Chinese tea during the revolution, leading to it being known as Oswego tea. It is widely planted as an ornamental, and is also found in the wild.

The children will be familiar with peppermint and spearmint flavors from gum and candy, but it is always a surprise to them that the flavor comes from a plant.

Other programs with herbs are mint jelly-making, herb drying (or "Yes, you can put thyme in a bottle . . ."), potpourris, and herb cooking.

The Pumpkin Patch

If space is no problem, a garden devoted to cucurbits (Squash Family) can be an effective teaching tool. Squash flowers are large, and fruits develop quickly, making them easy to study. Luffa sponges were not one of our more successful projects, but bird house gourds are easy to grow if your season is long. We harvest the gourds in fall and cure them for use in early spring.

It is always a marvel to watch an empty plot turn into a mountain of vegetation by August. By October, the most important product of the Pumpkin Patch is ready—Jack-O-Lanterns. The last session of each year is a Pumpkin Party. Pumpkin pies are eaten in copious amounts, and each child takes home a pumpkin for future carving. The season is over.

ABG

Children's Garden Activities
at Atlanta Botanical Gardens

CHILDREN'S HORTICULTURE IN ATLANTA

Brenda Dreyer

Children have a natural affinity for growing things, and we at Atlanta Botanical Garden have found that a judicious combination of work, play, and instruction effectively imparts a basic knowledge of gardening and horticulture and, more broadly, of nature and conservation. The ABG offers educational programs for children under a variety of different circumstances.

Junior Gardener Program

Junior gardeners (grades 3 through 6) attend a comprehensive program in greenhouse gardening on five consecutive Saturday afternoons in January and February. Registration is required and a minimum fee is charged. The child is introduced to soil mixing, basic methods of plant propagation, and the study of plant families, their culture and care. The "hands on" instruction enables each child to bring home a variety of plants throughout the course.

In Session I children are introduced to propagation. In the greenhouse they mix soils and learn to produce new plants from leaf and stem cuttings and seeds.

In Session II they study modified stems—bulbs, corms, rhizomes and tubers. They look at examples of each type and practice the pot culture of one or two kinds to take home.

Session III is strictly fun. A discussion of interesting plants which can be grown from fruits and vegetables begins the session. Most, including potatoes, beets, carrots, turnips, legumes, pineapples, grapefruits, oranges, and avocados, come straight from the kitchen. The youngsters practice a variety of techniques for growing these plants and draw lots to determine who takes home the culmination of our efforts.

Orchids, bromeliads, and succulents receive attention in our fourth session. The session concludes in the greenhouse where children learn to handle the tiny seedlings they have grown in Session I from seeds, "pricking out" the new seedlings and potting them up to take home.

The fifth session is our grand finale. The children line a wire basket with sheet moss and plant the rooted cuttings they have propagated. It is our belief that a genuine sense of accomplishment is generated by this course.

Children's Awareness Program

The Children's Awareness Program is designed to enable preschool and elementary school children to discover the wonders of the environment by using their senses. Registrations for this program are accepted throughout the year. The awareness program can be adapted to the capabilities, cultural backgrounds, and degree of sophistication of the children involved. It is a program that also adapts well to handicapped children, allowing them to enjoy learning in the outdoor classroom and to participate with confidence.

For many children the experience is a revelation. One morning, while touring with a group of young children, a guide asked if anyone knew what small animal with a stripe down its back made the tunnels beneath the rocks with the intent of eating the tender roots of the plants. Upon reflection one small child whispered solemnly, "I know, a zebra!" Also heard one morning in the vegetable garden was the very serious comment, "That ain't where you get potatoes; you get them at the grocery store."

The program will vary with the age of the group and the time of the year. On the nature trail, a preschool session might discuss animals that live in the urban woods, observe life in a rotting log (a lively discussion is sure to ensue), or look at the rings of a fallen tree. Another favorite, the "Web of Life" game, is played with the older elementary school youngsters to illustrate the dependency of plants and animals upon each other and the environment through a "web" of interrelationships, and to show what happens if the web is damaged.

The Children's Awareness Program is taught by volunteers trained in environmental leadership techniques which stress adaptability and flexibility. Volunteer-teachers are encouraged to make adjustments for the group he or she encounters while continuing to use the senses as much as possible. The result is to spark curiosity and stimulate thinking among the youngsters; in short, to plant a "seed" that will be nurtured and, with a little encouragement, flourish.

Children's Vegetable Garden

The growing season in the South is long. This enables a child to enjoy a bountiful experience in vegetable gardening. As participants in our first summer program in 1979 naively discovered, it can be a struggle, at the very least a challenge, to produce food from straight unamended Georgia red clay.

Our soil problems were solved with the creation of fifteen 8′ × 8′ raised bed garden plots funded annually by a local garden club. These have deep, well drained soil, making soil amendment and weed control easy. They also allow intensive planting.

Children register for the garden plots early in the season. They must be committed to the program for the entire summer because an absence of more than a week or two defeats the purpose. The program is open to any child willing to work hard and maintain his plot. We provide the opportunity, the children do the rest.

Upon registration each child is welcomed to the program by letter and receives a packet of study material in preparation for planting. A diagram of the 8′ × 8′ plot, a planting chart of the selected vegetable varieties, and a descriptive sheet, "How to use a Planting Chart," are included.

The gardens are planted early in May. Armed with study materials, a selection of seeds and plants chosen specifically for intensive gardening in a warm climate, and a volunteer or a parent for guidance, the children prepare the soil, mark off their plots, and sow the seeds. They return to tend their plots on Saturdays. During vacation time they work midweek, too.

Interspersed among these more tedious tasks are *enrichment programs* which help to make the whole experience of vegetable gardening a rich and rewarding summer experience. The children receive information about: soil—its layers, its decomposers and its minerals; how a plant grows; each vegetable chosen for their gardens; and insects apt to be encountered in a vegetable garden. Many participate in fun projects such as creating colorful waterproof row markers, making sungram prints of the flowers and vegetable leaves, and pickling a cucumber in a bottle.

We also encourage a recipe exchange to generate even more interest in the vegetables harvested. It's surprising how many gardeners have never eaten Swiss chard before, but like it. It's all in how an item is marketed! A fruitful time is in store for those who not only learn to plant, tend their crops, and harvest, but learn the reasons for mulching, weeding, caring for tools, and keeping records of the daily tasks accomplished.

Summer Experiences in Nature

Not every child can experience a vacation in the country, the mountains, the seashore or a week at camp. The Atlanta Botanical Garden offers a number of summer programs to enable the city child to explore nature in our meadows, woodland, and gardens.

On Tuesdays older youngsters may learn to identify a number of familiar trees using simple leaf keys and tree booklets. They may collect flowers, leaves, and plant materials to dry and preserve in plant presses at their disposal, or attempt to preserve nature through a variety of printing techniques. They can also create dish gardens of mosses and tiny woodland plants, and chase and net butterflies in the garden for identification. A favorite experience is to indulge in a close look at herbs, sampling their tastes and fragrances.

Thursdays younger children gather to enjoy nature hiking, storytelling, and games, or to grow plants from kitchen foods. They can explore making nature prints and craft items from the abundance of natural materials which we collect under supervision in and around the Garden. Alternatives to the outdoor activities are planned for an indoor situation in case of inclement weather. No program is ever "rained out."

The Future

Though relatively new in relation to long-established gardens, the Atlanta Botanical Garden has been dedicated to education from its beginning, and the future for education at the Garden is bright. A new building to open in 1985 will make additional classroom space available. Expansion into the adjoining fifteen acres of hardwood forest will bring added dimensions to our school outreach programs and summer experiences.

It is difficult to credit adequately the loyal corps of volunteers who assemble regularly at the ABG to make the educational programs thrive during all parts of the year. They are the backbone of our existence. We are ever cognizant of their valuable contributions to our commitment to education.

The education of Atlanta's children is vital to the Garden's mission. Because Atlanta is becoming increasingly urbanized, it is an increasing challenge to instill in her children a love and knowledge and respect for nature. The Atlanta Botanical Garden is uniquely situated and dedicated to meeting this challenge.

A County Demonstration Garden In England

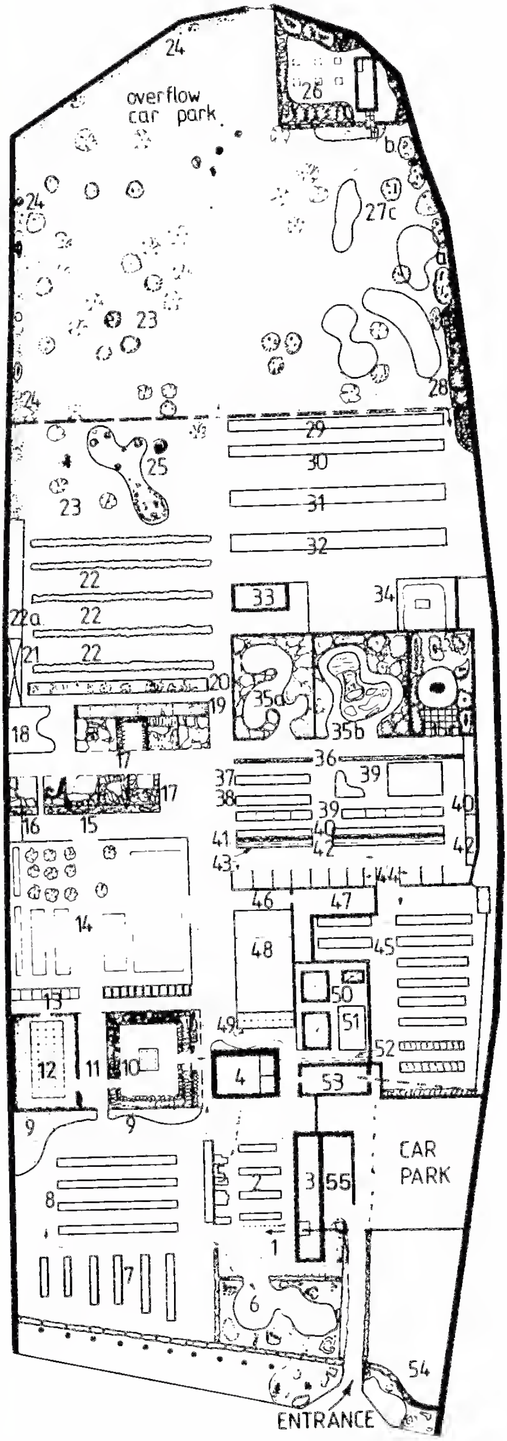
The County Demonstration Garden and Centre for Rural Studies, Probus, Cornwall, England, concentrates on providing models and information for schoolchildren and adults. The seven acre garden at Probus is basically used for courses for teachers to learn how to "tackle their task" in their schools. Children also visit the garden and are given guided tours by experts on the different methods of growing plants and shown how to beautify their own home areas by using plants, only two examples of many topics presented. A great amount of printed material covering garden design, plants to grow, and sections to teach is provided for teachers. Lists are also provided of available groups and organizations who are interested in helping school children in various aspects of environmental education.

To quote Peter Blake, County Horticultural Advisor and Advisor for Rural Studies/Science in Schools "[T]his subject is being taught as practically as possible since it is felt that if infants [kindergarteners] can be encouraged to grow plants . . . then later as adults they will also be involved. . . . It is my firm belief that much should be done in schools to encourage all people to look at their plots of land that surround the houses and bungalows and see how those plots of land can be utilized to best advantage, making them attractive or productive or both. This process should start in schools. Individuals can make a major contribution towards making the environment more beautiful and the soil more productive. Or perhaps . . . simply understanding what the farmer and gardener are trying to do." —*Editor*

Herman Gantner

CORNWALL EDUCATION COMMITTEE

COUNTY DEMONSTRATION GARDEN



GARDEN ROUTE

1. Patio gardens;
2. Container gardening;
3. Wall plants;
4. Demonstration hall;
5. Garden for retirement;
6. Labor-saving garden;
7. Trial plots;
8. Roses;
9. Shrubs for shade;
10. Historical garden;
11. Herbs, culinary;
12. Children's garden;
13. Herbs, medicinal;
14. Fruit demonstrations;
15. Flowers and plants for shade;
16. Ferns;
17. Front-garden designs;
18. Scree garden;
19. Aspects of vegetable growing;
20. R.H.S. Vegetable plots;
21. Composting/green manuring;
22. Shrubs for exposure;
23. Ornamental trees;
24. Eucalyptus "trial";
25. Miniature conifer "trial";
26. Apiary;
27. Environmental studies area:
28. Bamboo collection;
29. Tree planting and staking;
30. Shrub pruning methods;
31. Hydrangea collection on aeid and alkaline soils;
32. Heather collection;
33. Small vegetables and fruits;
34. British dye plants;
35. a.b.c. garden designs;
36. Climbing plants for wire fences;
37. Garden pinks;
38. Lilies;
39. Annuals;
40. Hardy fuchsias;
41. Artificial windbreak;
42. Narcissi collection;
43. Natural windbreak hedges;
44. Paving designs;
45. Outdoor propagation unit;
46. Artificial lawns;
47. Hard landscape materials;
48. Lawn trials;
49. Ornamental grasses;
50. Amateur greenhouse display;
51. Cloches;
52. Labeling methods;
53. Propagation house and collection of educational plants;
54. Foliage shrubs;
55. Plants from different countries.

Activity and Project Garden

A carefully designed "School Garden" can provide excellent opportunities for children to become closely and individually involved in: growing and caring for plants; observing animals; studying soil; and many other similar activities. These activities *with* personal involvement can result in real and lasting experiences resulting in better understanding of: how plants grow; how animals (pests) feed; how man is dependent upon the soil to grow food we and animals require to survive; how man is able to help plants to grow better (Applied Science).

The activity/project garden should be clearly defined (in contrast, for example, to nature trails). The garden should have an appropriate sign indicating the purpose of the area. Plants and methods of cultivation should only be introduced if the activities likely to be pursued by the children will have real educational values/potential. Maintenance needs should be kept to the absolute minimum. There is no justification for repetitive weeding or sweeping!

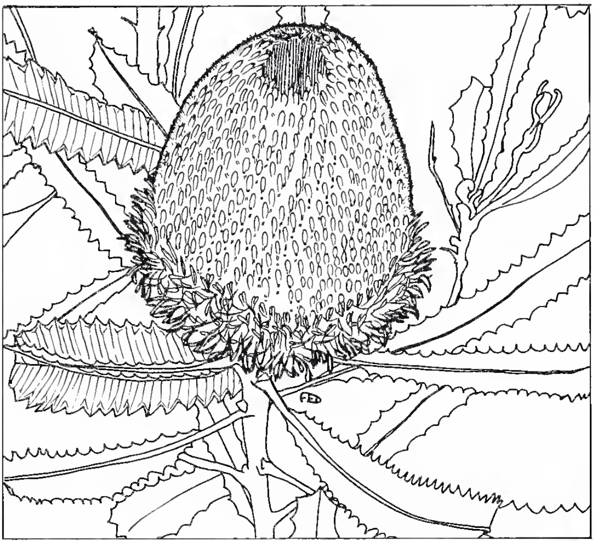
Sections which have much education potential and which should be included

1. Areas to grow own food (mustard, cress, lettuces, radishes).
2. Areas to grow flowers (to make area more colorful and to take bunch to Mum, etc.).
3. Trial demonstration area for special projects, individual and group activities (Do plants need to be thinned to grow well? Sowing at different depths and other related activities).
4. Practice plot (to demonstrate and practice use of tools).
5. Fallow plot (observe weed growth in uncultivated soil).
6. Pond
7. Bird Table
8. Plants of economic, historical, geographical and other similar interests and associations.
9. Weather station

Other Educational Projects in the Garden

1. Comparing the temperature of dark soil with that of light soil.
2. Thinning and not thinning rows of carrots or lettuce.
3. Feeding and not feeding a row of vegetables.
4. Feeding and not feeding lawns.
5. Using cloches to protect crops and compare with unprotected crops.
6. Growing potatoes under black polythene.
7. Comparing the earliness of flowers—e.g. hardy annuals, sown on the same day.
8. Comparing the times blooms will last in a vase of water.
9. Sowing seeds at different depths.
10. Comparing the rate of growth of broad beans sown at three weekly intervals.
11. Digging and *not* digging—growing simple and quick crops across both plots.
12. Weeding and *not* weeding.
13. Temperature in a compost heap.
14. Protecting young plants (peas and beans) with jam jars. ❦

C.B. Grafton/Dover Publications



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Banksia burdetti

ENCOURAGING AUSTRALIANS TO GROW NATIVE PLANTS

Anne Boden

Australia has received three waves of human immigration. The first began at least 40,000 years ago and gave rise to the Aboriginal race. Migration of the second wave, mainly British people, dates from the establishment of a penal settlement at Sydney Cove in 1788. Government sponsored programs following World War II stimulated the third wave of settlement, initially from Europe and more recently from Asian countries.

Although early botanists were fascinated by Australia's unusual plant life, most European settlers found their new environment somewhat forbidding. To overcome their feelings of homesickness people established gardens of the familiar plants of British horticulture. The exotic nature of Australian home gardens persisted for more than a century before the horticultural potential of the local flora was finally recognized. The last twenty years have seen an enormous increase in public interest in Australian native plants and their cultivation. No doubt this trend will intensify as Australia approaches its bicentenary of European settlement in 1988. The National Botanic Gardens situated in Canberra in the Southeast house the national collection of Australian plants and currently have about five thousand species in cultivation. The Gardens play a vital role in growing native plants for display and in fostering in local and overseas visitors a knowledge of Australia's plant heritage.

Posters and Applied Gardening

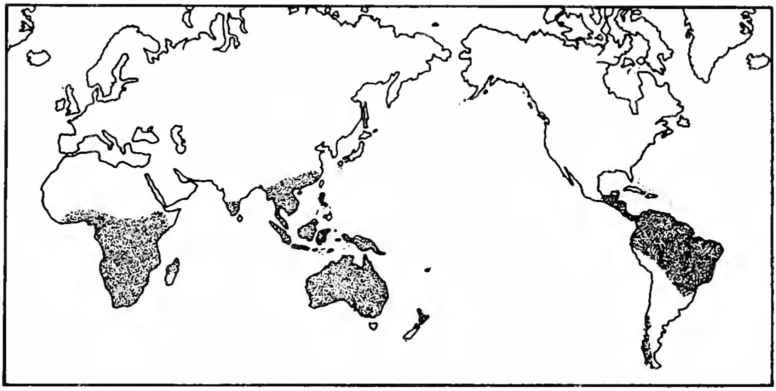
The educational needs of student visitors are catered to in the Gardens' lesson programs which include minicourses in plant propagation and single-session visits on aspects of plant biology. Education at the Gardens extends learning within the school environment and provides direction and focus for follow-up activities. An

AUSTRALIAN NATIVE PLANT FACT SHEET

Prepared by the
National Botanic Gardens, Canberra.

Approval is given to schools for multiple copying
of this sheet for distribution to students.

Banksia burdettii
Family: Proteaceae
Number of genera: about 60
Number of species: over 1,000



World distribution of Proteaceae
(after Johnson, L.A.S. and Briggs, B.G 'On The Proteaceae', Bot. J. Linn Soc., Feb. 1975)

Proteaceae is an important family in the Southern Hemisphere, especially in areas with long dry seasons. It also extends to tropical and some sub-tropical areas of the Northern Hemisphere.

Australian genera include *Telopea* (waratah), *Grevillea* (spider flowers), *Lambertia* (mountain devils), *Banksia, Hakea* and *Macadamia* (Queensland nuts or bopple nuts).

Telopea speciosissima (waratah) has spectacular red flowerheads and is grown for the cut flower trade both in Australia and overseas. *Grevillea robusta* (silky oak) is a tree with brilliant gold flowers and attractive divided leaves. It yields fine timber, and young plants are suitable as indoor plants. In India silky oak is grown in tea plantations to provide shade and shelter for the tea plants.

Flower spikes are gathered from some *Banksia* species grown for the cut flower trade, or harvested from the wild. Early settlers at Sydney Cove dipped dry *Banksia* spikes in tallow to make crude candles. *Macadamia tetraphylla* and *M. integrifolia* (Queensland nuts) occur naturally in coastal areas of New South Wales and Queensland. Cultivars of these species are grown in plantations in Eastern Australia and Hawaii.

Some species of *Protea*, a South African genus, are grown for the cut flower trade in Australia. *P. cynaroides* is the floral emblem of the Republic of South Africa.

Printed and distributed by courtesy of KODAK (Australasia) PTY. LTD.

Genus: *Banksia*

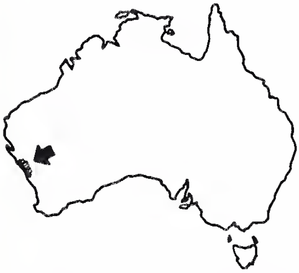
There are 72 species of *Banksia*. Fifty seven species are confined to south-west Western Australia, 14 species occur in eastern Australia and one is distributed across tropical Australia and in southern Papua New Guinea and nearby islands.

All *Banksia* species are trees or shrubs. Some species are fire-tolerant, having either dormant buds protected within a swollen basal part of the trunk (lignotuber), or thick bark protecting the truck. Species lacking either of these features are fire-sensitive. They are killed by fire and regenerate only from seed.

Individual flowers are small but very numerous and tightly arranged in an inflorescence around a central woody axis.

The individual fruits are woody and grouped in a massive woody structure (infructescence) sometimes described as a cone. Each fruit contains two winged seeds. In some species the fruits open spontaneously when the seeds are mature. In other cases fire is needed to open the fruits to allow seed release. The winged seeds spin as they fall and they are dispersed by the wind.

The seeds of most *Banksia* species require no special treatment before sowing. They usually germinate readily if sown in well drained sandy soil or seed mix, and kept moist.



Australian distribution of *Banksia burdettii*

Banksia burdettii

This shrubby species is confined to south west Western Australia where it occurs in tall shrubland on deep sandy soils. Its distribution is very restricted, and while it is not currently classified as an endangered species, its status in the wild is vulnerable. Clearing its habitat for agriculture has reduced the number of plants of *B. burdettii*. However populations in Alexander Morrison National Park should be safe if managed carefully.

B. burdettii grows to 4m, is bushy in habit and lacks lignotuber. Each inflorescence develops at the end of a branchlet less than one year old. Inflorescences are 7-8cm wide when the flowers are mature and 6-10cm long.

Flowering occurs between late January and May. This species is cultivated for the cut flower trade. It requires well drained soil and tolerates light frost. Propagation is from seed which is available through commercial suppliers.

Text: Anne Boden, National Botanic Gardens, Canberra.
Photograph: Murray Fagg, National Botanic Gardens, Canberra.
Sketch: Fay Davies, National Botanic Gardens, Canberra.

example of this principle is seen in a set of poster kits recently prepared as a joint venture between the National Botanic Gardens and Kodak (Australasia) Pty Ltd. Three full color posters for classroom display depict *Acacia pycnantha* (golden wattle), Australia's unofficial floral emblem, *Banksia burdettii,* a threatened species from Western Australia, and *Correa reflexa* (native fuchsia), an eastern Australian shrub cultivated in temperate regions of the United States and other countries. Each poster is supplemented by a fact sheet providing information on the relevant family and genus, and details of the occurrence, propagation, and cultivation of the featured species. In addition there is a fact-finding sheet to develop students' skills in reading, comprehension, observation, and library research, a sketch sheet for younger children to color and a teacher's guide to the educational use of the kit.

When the poster kits were launched in an outdoor ceremony at the Gardens, students from Campbell High School applied skills acquired in a plant propagation mini-course at the Gardens and invited guests observed the students carrying out propagation techniques from sowing seeds to potting seedlings and rooted cuttings for growing prior to planting out of the plants depicted in the posters.

Like most Australian species of *Acacia* (Mimosa Family), treating the seeds of *A. pycnantha* with hot water increases rates of germination. This treatment is thought to duplicate the effect of bushfires on seed buried by ants in the upper layers of the soil.

The students demonstrated seed sowing techniques and methods of pricking out seedlings of this wattle. They were keen to explain the transition from true leaves at the newly emerged seedling stage to the phyllodes which develop at about the fifth "leaf" stage. The phyllodes are thought to be an adaptation to the moderately low rainfall of the species' distribution. The green "leaves" and fluffy, golden round flowerheads of Australia's national flower are the origin of the colors worn by Australia's sporting representatives at international events such as the Olympic Games.

The second poster subject, *Banksia burdettii,* belongs to the Protea Family, important in the Southern Hemisphere. *B. burdettii* occurs in a very restricted area of southwest Western Australia where its status in the wild is classed as vulnerable because of habitat clearing for agriculture. The seeds are retained on the parent plant until the woody fruits open as a result of bushfire or the death of the plant. The students showed the method of extracting seeds from the "cones" (massive woody structures containing the fruits) which had been doused in alcohol and ignited.

Although the extracted seeds germinated well under conditions in the Gardens' education glasshouse, this species requires deep, well drained soils and a mild climate for successful cultivation in home gardens.

The third subject, *Correa reflexa* in the Rue Family, shows wide variation in flower color, leaf shape and texture, and plant form. The form of this shrub selected for the poster has bright red tubular flowers tipped with greenish yellow. Cuttings of most forms of this species root readily and this propagation method is used to perpetuate desirable forms. The students demonstrated the preparation of cuttings, including treatment with a plant hormone solution. The demonstration also included the potting up of rooted cuttings and a display of potted specimens produced by the students during their end-of-summer term program at the Gardens.

Feedback from teachers and parents shows that many students attending plant propagation programs at the National Botanic Gardens take their new skills into later life and become keen participants in home gardening, a popular leisure activity in Australia. The education programs of the National Botanic Gardens are intended to enrich students' understanding of the Australian flora for its biological interest, intrinsic beauty, and horticultural merit. The Education Service of these Gardens shares the ideal expressed in the couplet over the entrance to the Children's Garden House at Brooklyn Botanic Garden:

> He is happiest who hath power
> To gather wisdom from a flower.
>
> —Mary Howitt, 1847

Community Gardening in New York City

Doris Sargeant

The New York City Housing Authority sponsors annual gardening competition in two categories—vegetable and flower gardens. In 1983, 1,234 groups participated. Sixty-three of these groups were entered as children's gardens and 412 were entered as "mixed," indicating participation by all ages. While the remaining 759 registered as adult groups, we know that many had children working with them.

Each group leader is provided with $27 for the purchase of plants and/or seeds. Choice of what to plant is up to the individual gardeners. Demonstration gardens are planted each season—one in Brooklyn and the other in the Bronx. On designated days, experts are on hand to answer questions. Response to this portion of the program varies from season to season. Problems and queries are also answered by telephone and horticultural experts are often consulted. At the beginning of each spring season a meeting is held for participants. Here assistance is also provided.

Aside from the competition, the Garden Program offers a variety of activities for children which include botanical tours, bulb planting, seed planting, potting seedlings,

Photos from the New York City Housing Authority

A vegetable garden in a Brooklyn public housing yard went on to win an Honorable Mention.

The Second Prize went to this Brownsville, Brooklyn, flower garden featuring salvia and impatiens.

and classes on garden insects. Classes are held in the housing projects to eliminate transportation difficulties. Arbor Day programs are an annual event. Garden craft classes are also offered. The current craft project is a three-week series of workshops in which musical instruments are being made from ornamental gourds.

[*Ed. note:* As one of the judges of the gardening competition in late summer of 1983, I saw many of these gardens. The resulting efforts of the entrants were awe-inspiring. Vegetable gardens, surrounded by concrete and shaded by tall apartments, abounded with produce. The pride of the gardeners in what they had accomplished was reflected in their smiling faces. Awards' Day at City Hall brought winners together to receive trophies and bowls presented by the Mayor of New York, the Honorable Edward Koch.

The comments of the judges are available to entrants upon request.]

GARDENING WITH SIGHT-IMPAIRED CHILDREN

Shelley A. Wine

One blind New York man now grows roses, tulips, and tomatoes on the roof of his apartment despite the unkind and misguided childhood warning of "Don't touch the flowers, they'll die!"

For the blind youngster to grow plants is an essential part of the learning process. Without the opportunity to grow a crop of peas or tomatoes, or to take a trip to a "pick your own" pumpkin patch the blind child, even with the most articulate parent or teacher, will have missed the link between seed-soil-seedling-nurture-growth-flower-fruit-harvest, and that people, animals, and cultivated plants, are interdependent.

What to Grow

The child who has some useable vision will find foliage and flower color fascinating. Coleus, mums, roses, spider plants, and the soft gray of dusty miller offer a variety of colors. Hard and fast rules of what plants to use and grow are difficult to make

Bert Andrews

BBG's Fragrance Garden is waist-high and has labels in English, Latin, and Braille. All plants can be touched, picked, and, of course, savored for their fragrance.

because each blind student is an individual with his or her own preferences.

Children enjoy textures such as lamb's ears, African-violet leaves and peppermint geranium's velvety leaves.

The sense of smell is a funny variable. To some, gardenias and paperwhite narcissus have the most exquisite scents, others find them overpoweringly sweet. Some blind youngsters don't care for the smell of roses.

Plants that don't injure easily are excellent choices for growing. Pineapples and other bromeliads are interesting and almost indestructible. Succulents are successful under a wide range of light and heat conditions and those without spines can be touched without harming the plants.

It seems prudent to mention what *not* to grow. If the blind child is at the stage where: "if it's interesting it has to be tasted," then avoid any and all plants known to be irritating or toxic. The poinsettia belongs to a large family of plants, the Euphorbiacae, whose sap can cause rashes. Tomato and potato plants contain toxic substances. Daffodils, too, are not to be nibbled. To obtain a list of poisonous plants, contact your local Poison Control Office or BBG Plant Information Service.

Share Your Own Experiences

If you, as a parent or teacher, have had success with gloxinias or geraniums then by all means share this experience with the children. If your thumbs are "black" or "purple" and only sweet potatoes will grow in your classroom, then involve the child with training sweet potato vines to twine up a string. No matter how simple the experience, I personally feel that day-to-day hands-on experience with growing and studying plants is essential and perhaps even more important than going only occasionally to a trail "for the blind" or a "fragrance garden for the blind."

How to Teach Abstract Concepts

How do you teach abstract concepts such as color, the existence of spores or the process of insect pollination? Begin with what excites *you*.

If colors excite you, go ahead and describe the azalea's bold pinks and oranges. The child is developing color associations such as snow/white, sun/yellow, night/black, and this skill needs strengthening. Tactile exposure to the many faces of flowers will enrich the young person's appreciation of the flowers used symbolically in literature.

Models are an invaluable tool for teaching the abstract. I use plasticine (pliable modeling clay) to demonstrate a concept when words fall short. For example, my class was about to plant a little mushroom farm in a box. The students were spreading the spawn and one asked, "How does one mushroom make another one?" With the modeling clay I formed a mushroom, about the size of the ones we were anticipating and helped students learn where the spores are formed in mushrooms.

Allow enough time to pass materials around. Whether you have one student who is blind or has limited vision, or ten, be certain that each student handles everything you are discussing; otherwise the students will become frustrated. With a group of ten, passing a sample from person to person can take considerable time. Therefore it is better to have several samples ready.

When teaching blind children you will find that you are talking a lot. This is necessary to help fill them in on the information they can't perceive. Keep in mind the most important information that must be conveyed. I have found that the more I share my excitement, the more the children become involved. For example, describe a bee collecting pollen from a flower. The child's involvement will, in turn, generate questions which are really the key to what he or she wants to know more about.

Go places. Learning must go beyond the classroom although it need not be an elaborate field trip. Discover what is growing between the cracks of the sidewalk. How many different kinds of plants can be found in one square foot of meadow?

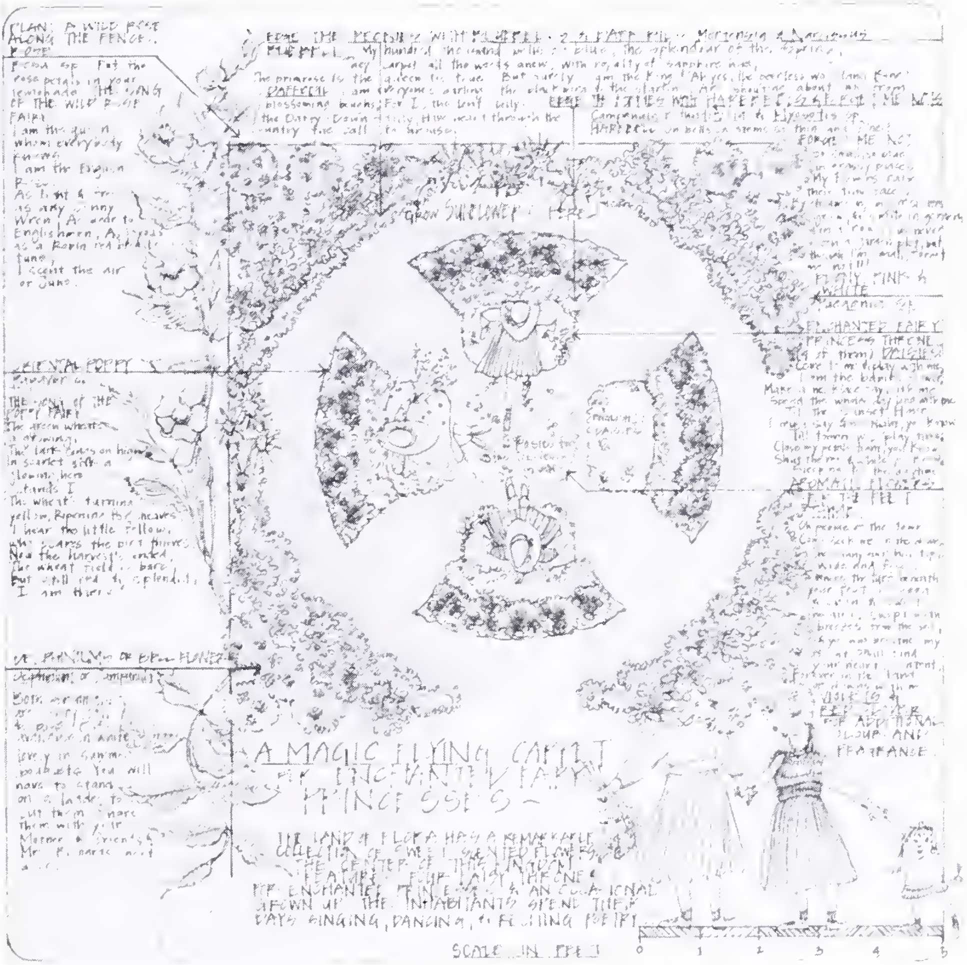
How can a blind child "know" a tree? That is, without climbing one? I am not overly protective of blind children and believe they have a deep need to experience *all* the scenery (through all the means above), that the sighted can absorb in a glance. ❦

GARDENS DESIGNED FOR CHILDREN

Barbara Paca Steele and St. Clair Wright

Some of our most unforgettable memories from childhood involve garden imagery. When one reflects upon the childhood garden (or the magical garden that was wished for) nostalgic visions, pathways leading to unknown places, colorful plants, and unusual scale conjured up. T.S. Eliot sums up this attachment to our childhood.

Footfalls echo in the memory
Down the passage which we did not take
Towards the door we never opened
Into the rose-garden.[1]


PLAN: A WILD ROSE ALONG THE FENCE
ORIENTAL POPPY
A MAGIC FLYING CARPET FOR ENCHANTED FAIRY PRINCESSES
THE LAND OF FLORA HAS A REMARKABLE COLLECTION OF SWEET SCENTED FLOWERS.
FOR ADDITIONAL COLOUR AND FRAGRANCE
SCALE IN FEET
0
1
2
3
4
5

"A Magic Flying Carpet for Enchanted Fairy Princesses"

---

[1] Eliot, T.S., *Four Quartets*. "Burnt Norton". London, 1944.

As adults, it is a difficult task to identify and describe the special qualities which are unique to children's gardens; however, in this article we will attempt to do so.

The Elements of Design

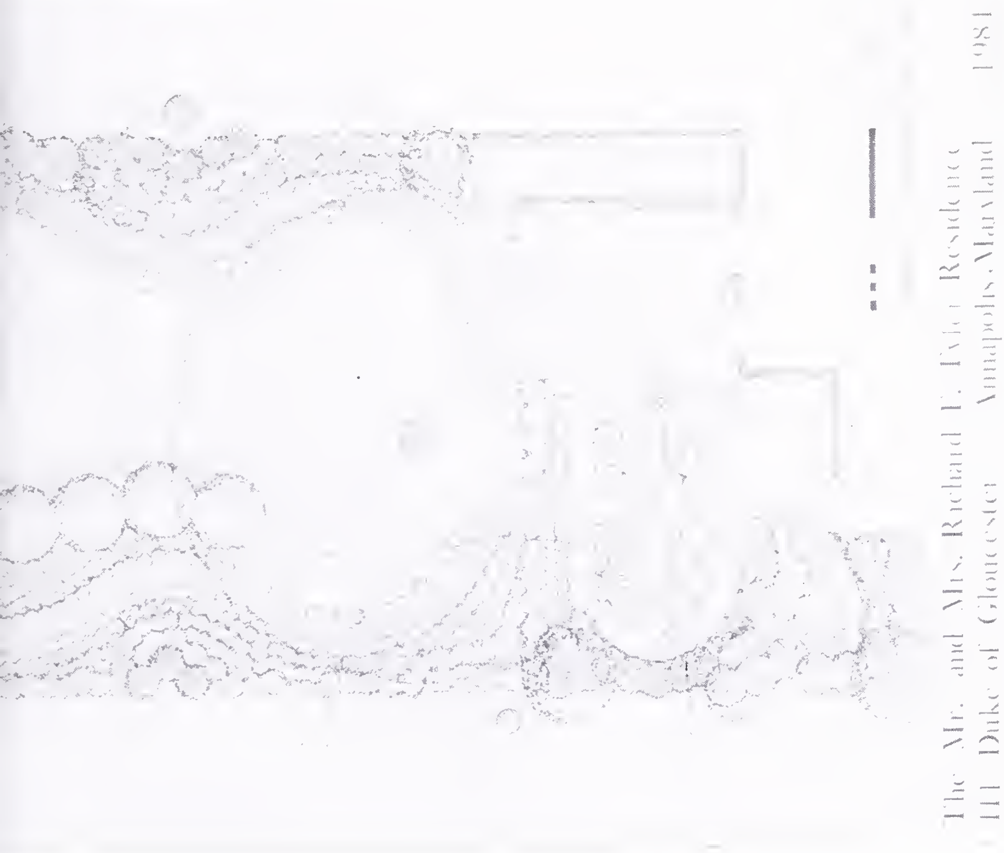
In designing children's gardens, thought should be given to the following:

The garden should be of a child's scale. Make the paths narrow (12″–18″ wide), use small specimen plants, and when wanting to create a feeling of enclosure remember that plants need not exceed 5′.

The garden should be a place for learning. Teach children the art of gardening in an outdoor setting, familiarize them with many plants by using a variety of cutting flowers, herbs, vegetables, and trees.

The garden must be safe. Protect the children's garden from the street by encompassing it with a dense thicket. Keep their play-area within the view of adults. DO NOT use poisonous plants in their garden. Pretty bell-shaped flowers such as foxglove and monkshood are of interest to children, but are very toxic. The garden should offer both sun and shade. Sunshine is healthy for children, but it is important to guard them from overexposure.

The children's garden should be a place which is their own domain. The area should allow for the entertaining of other children and create an environment which is detached from adults. It is important that their garden be in view of adults, yet semi-private. A child's perception differs from that of a grown-up. Their view of the world is of a smaller scale, and therefore, more immediate.


The Mr. and Mrs. Richard E. Tyler Residence
111 Duke of Gloucester Annapolis, Maryland 1981

The garden should be a place for a child's imagination to blossom. When children are allowed to play among themselves, their creative disposition transforms them into gypsies, soldiers, and fairy princesses. This ability to explore should be encouraged and nurtured amongst the flowers of their own magical gardens.

Examples of Garden Design For Children

Following are three approaches to children's gardens by St. Clair Wright and Barbara Paca Steele:

A garden for Jacqueline and Torri Tyler (ages 4 and 7) Annapolis, Maryland.

A horizontal axis beginning at the house is ended by a rose parterre (with seating) which is surrounded by a sunny cutting garden.

Another cutting garden using mostly shade-tolerant flowers runs along a serpentine walk. This area is followed by a "Magical Flying Carpet for Enchanted Fairy Princesses,"[2] the cutting garden for Jacqueline and Torri. In the center is a seating area of small aromatic flowers and herbs for picnics with friends.

At the end of the serpentine walk and on the edge of the "wilderness terrace" is a pavilion for the children. The wilderness garden beyond is a large grassy field encircled by a thicket of plants which offer a variety of colorful flowers, fruit, and berries. This picturesque backdrop is an impenetrable barrier for outsiders, thus keeping the children safe.

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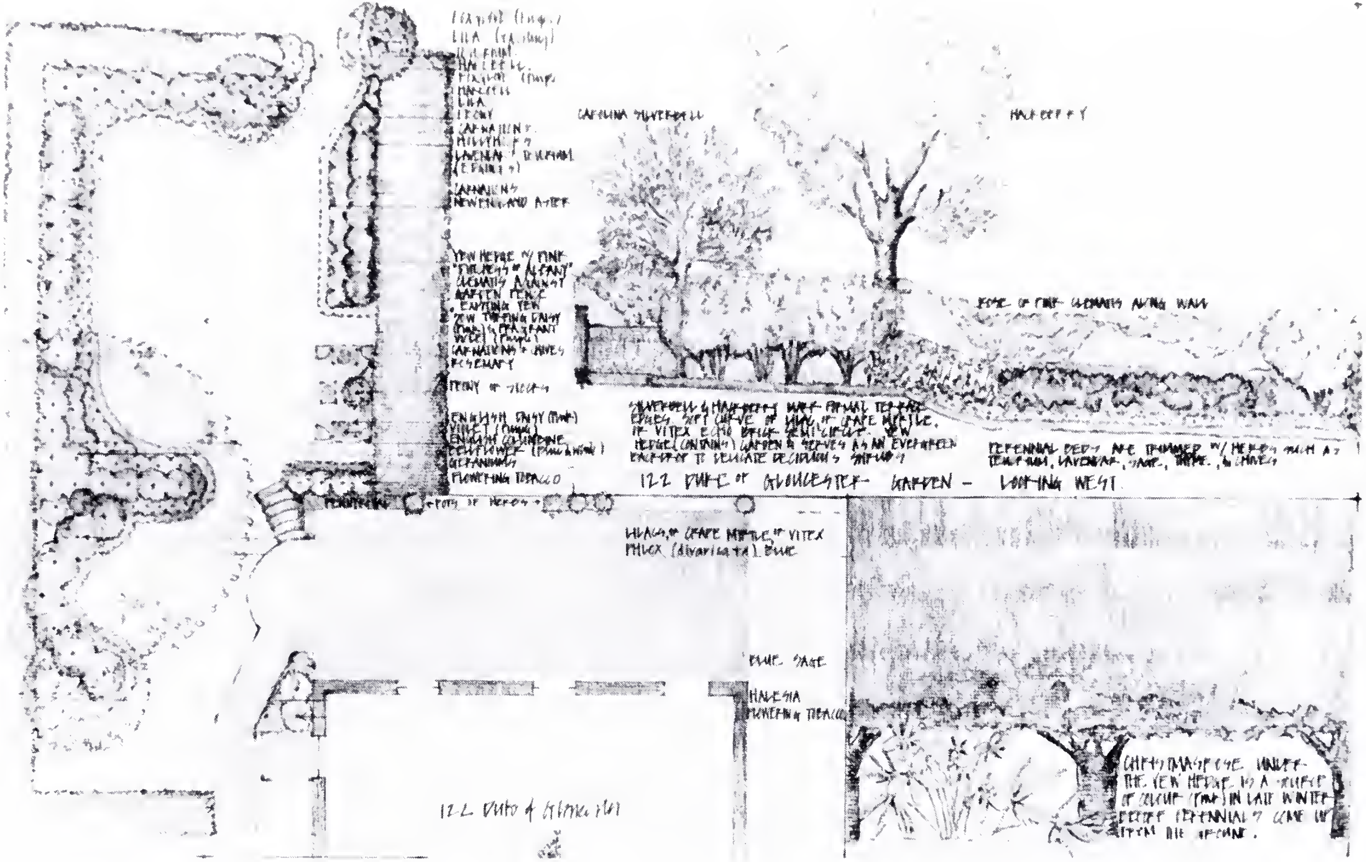
[2] Coats, Alice M., *The Treasury of Flowers.* New York: McGraw-Hill Book Co., 1975.


CAROLINA SILVERBELL
HACKBERRY
12.2 DUKE OF GLOUCESTER GARDEN – LOOKING WEST
LILAC, OF CRAPE MYRTLE, OF VITEX
PHLOX (divaricata) BLUE
PERENNIAL BEDS ARE TRIMMED W/ HERBS SUCH AS
LAVENDAR, SAGE, THYME, & CHIVES
BLUE SAGE
HALESIA
FLOWERING TOBACCO
FLOWERING TOBACCO
12.2 Duke of Gloucester

A garden for Miss Elisabeth Struse (age 18 months) Annapolis, Maryland.

A formal axis running from the house terrace is terminated by a clump of pale lilac crape-myrtles. There is a small play area under the trees.

An unusual feature is the "table-setting garden," which is based upon an innovation by the mother of Carl Linnaeus. Violets and carnation place settings are arranged about a planted centerpiece of fragrant stocks.[3]

The "witches garden" uses a border of historically unfriendly plants to serve as a barrier, thus discouraging children from wandering into the adjacent garden.

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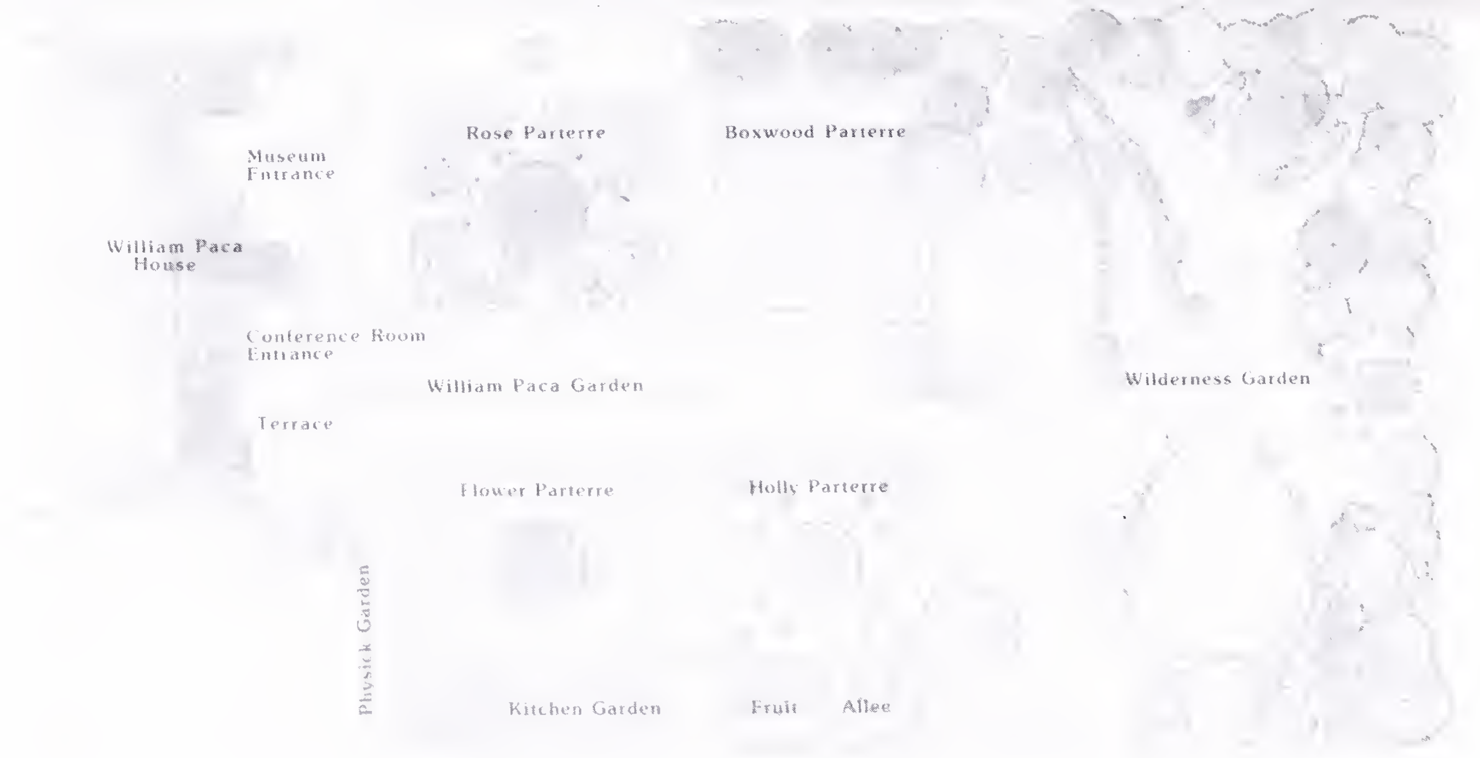
[3] Blunt, W., *The Compleat Naturalist: A Life of Linnaeus*. New York: The Viking Press, 1971.



The William Paca Kitchen Garden for All Children (ca. 1763) Annapolis, Maryland, is a restored 18th century neo-classical garden. This fine example of garden preservation is open to the public. The William Paca Garden features the Kitchen Garden, an area for children, which serves as an effective tool for educating children about the diet of Colonial families.

4′ × 8′ knot beds are of an ideal size for close inspection of herbs and vegetables by children. Old fashioned herbs and vegetables are planted in delightful geometric patterns, which children are able to view in their unhybridized form. Gourds, used in making Colonial ladles and bowls, playfully hang from a Chippendale arbor.

For children, the Kitchen Garden is a refreshing break from the rest of the William Paca Garden where the formal character requires that children behave.

Any garden, especially those for private residences, should be a source of delight for its inhabitants; the design is, therefore, a personal matter. Perhaps the concept of a children's garden stems from a collection of childhood memories, and the desire to continue that tradition attracts us to our own past and the door which we have never opened.

EXPLORING CITY ENVIRONMENTS WITH CHILDREN

Lucy E. Jones

Environmental education is a modern version of nature study that includes environments made and affected by humans as well as natural environments. Nature education has been popular since Anna Botsford Comstock of Cornell University published the *Handbook of Nature Study* in 1911. The American Nature Study Society was founded at Cornell in 1908 by Liberty Hyde Bailey, the eminent horticulturist, after he became alarmed over the massive movement of people from farms to cities.

How To Begin Your Own Program

If you would like to start a children's program exploring city environments, begin by exploring on your own. What can you find within a city block? Are there street trees and city parks nearby? What can you find growing in a sidewalk crack? How does a paved street feel different from a weedy vacant lot? Be open to the numerous possibilities for nature in the city. Within an hour, you may find a tree stump with its seasonal rings, a spore-producing moss growing in a stone wall, lawn weeds that are producing flowers, or mushrooms growing at the base of a tree. Find a tree with a community of insects living beneath its peeling bark. Determine a path for a later exploration with children in tow.

The thought of roaming the streets with a group of unruly children may send chills up the spine of a more conventional teacher, but if the children are prepared and the trip is planned and guided, it can be a very rewarding way to excite children about learning. For good interaction and control, keep the group small. Six to ten children for each adult is a good ratio.

After doing your own neighborhood search, decide what concepts can be illustrated by the objects you have found. Before taking the children into the streets, explain what they will be doing and why. The many distractions outdoors and the high level of involvement you want to foster make it difficult to convey philosophical abstracts in that setting. Better to do that part of the session indoors, preferably before the walk outside. The outdoor setting stimulates more activity-oriented lessons. Sessions that end with sharing individual experiences can reiterate the facts and feelings gained.

Introduce them to the elements of plant life: light, air, water, and soil. Create a "magic box" with two plastic bottles, one holding soil and the other water. As the box is opened, light becomes part of its contents. Air is the important invisible ingredient. Use the box to dramatically introduce these elements. Ask the children to guess the ingredients. Then explain that plants use them to make food.

Moving Outdoors

Lead the group on a walk to find all the things in your neighborhood that use energy. Make a list of the living things that move. Does each thing on your list have its own energy, or does the energy come from an external force?

Add to your list the non-living things which you see moving: automobiles, a railroad crossing bar, bicycles, water, a weathervane, a flag. Then name the energy source causing each one to move: gasoline, electricity, people, gravity, wind. Explain to the children that the sun produces our energy as food, wind, water, and even petroleum fuels (which were originally

William Carnahan/USDA

In the shadow of highrises, young city gardeners can still experience much of the wonder and excitement of less urban children.

prehistoric plants and the animals, such as dinosaurs, which fed upon them).

Based on how energy is stored and used, living things operate as producers, consumers, or decomposers. Green plants are the primary producers. This can be understood in a vegetable garden where plants are grown to provide food for humans. Consumers are living organisms that do not make their own food but feed on other organisms. In a vacant lot, garden, or park, search for producers, consumers, and decomposers, and the evidence of their relationships to each other. You may find a butterfly or bee pollinating flowers, plant galls formed by wasps, or a person eating a tomato. Even insect damage, such as chewed leaves, is proof of the food cycle.

In a community garden look for a compost pile as evidence of decomposers. Decomposers are so small that most can not be seen. They're at work when the organic matter shrinks over several weeks, and when you feel the warmth in the pile caused by the decomposers' respiration.

Change and Succession

Just as decomposers are reducing organic waste to its basic elements, so everything is becoming something else. Change is difficult to discover at any one time, but it can be observed over a period of time. Growth of an individual is a form of change. So is plant succession where a community changes over a period of time, such as when an old field or meadow becomes a wooded forest. One way of seeing the variety of changes a piece of land has gone through is to observe the variety of living organisms in the vicinity. To find this diversity, take a close look at the ground you walk over daily. Find a lawn that has not been mowed within a week, and have the children sit down and pick out as many different kinds of plants as they can find around them. These can be distinguished by the leaves and by the flowers.

Instruct children to look for the leaves' veins. Are they parallel, pinnate (with a midrib and the veins branching off, like a feather in form), or palmate (all the large veins meeting at the base of the leaf as the bones of one's fingers do at the wrist). Have children make leaf rubbings of each type of leaf by rubbing a crayon on a piece of paper with the leaf underneath the paper.

Look for the flowers on the plants and compare the different varieties. Seek out any animals such as beetles, earthworms, grasshoppers, and others. Have the children speculate why so many different kinds of plants and animals exist.

The diversity of even a small piece of land shows us how many different things live in the city. Another principle to remember is that everything has a home. Some plants and animals can live in a city, but others, such as pine trees and beavers are displaced by the air pollutants or high population densities in cities. Plants that have adapted well to the city take advantage of the space and resources no longer used by displaced species. They often have weedy characteristics that make them tough competitors once they become established.

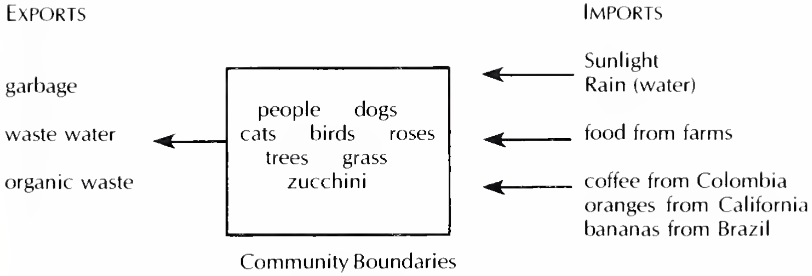
The ailanthus, or tree-of-heaven, for example, can grow where nothing else can. Tolerating air and water pollution, it grows quickly with very little soil and combats insects with offensive odor and taste. Dandelions have also made a home where other plants have more trouble growing. Try to pull up a dandelion plant. Its deep taproot is difficult to dislodge. Crush an ailanthus leaf and smell it. That odor probably fends off insect attacks. Look for seeds and how they are dispersed. Dandelion parachutes are carried away by the wind and ailanthus keys or samaras are blown far from the parent plant.

Identifying Communities

The homes of plants and animals within a defined area form a community. A square inch of soil can be considered a community; so can the entire earth. The more limited the scope of the community, however, the more it is dependent on outside sources for its needs. It also must dispose of or export any excess matter that cannot be used in its internal cycles.

Armed with paper and pencil, take the group outside for a walk down a city street, through a neighborhood, and into a nearby park or garden or vacant lot. As you walk, have the children list things that live in the community: people, trees, flowers, grasses, insects, cats, dogs.

After you have acquired a list, sit outside in a circle and talk about what you found. Ask the children to identify what these organisms need for life. Are their needs supplied from within the community or from the outside? Draw the community as a box to illustrate boundary lines. Write the imports on the outside of the box with arrows pointing into the community. Are there any exports? Where does trash go? Where does waste water and sewage go?



Draw arrows indicating the excess materials in the community that are not cycled back and label them "exports."

Does it matter how much we export out of our city? Remember one ecosystem's export is another's import. What might happen if there was no place left to put garbage and sewage and nuclear waste? What would the effects be on the human community?

While walking back to your starting point, have the children look again at the living components of the community, but this time instead of calling out what the plant or animal is, call out what must be imported for that plant or animal to live where it is and what it must export to live where it is.

Cooperation and Competition

We have seen that plants and animals grow where they can get what they need to survive, but there is another important principle that influences the components of a community: relationships with other living things in the community. Living things interact by working together in cooperation, against each other in competition, or independently without interaction.

Explore your neighborhood looking for examples of plant or animal populations that work against nearby populations, or work in cooperation. If there is a community garden nearby you can compare two plots with each other. Find two similar plots, but one weedier than the other. Or compare a vacant lot with a cultivated yard or garden.

Weedy plants invade the untended garden because they have special qualities that give them a competitive advantage over more desirable plants. They can grow quickly and spread rapidly with a minimum of water and nutrients. Their seeds can wait in the soil until the moment is right and then spring into growth.

Investigate how the plants compete for sunlight. See how the faster-growing plants shade the slower-growing or younger plants. How do the plants compete for soil water and nutrients and space? Pull up some weeds. (Don't pull crop plants without permission!) Is there any difference between the roots that plants form? Compare the size of leaves and stems of different plants. Look for ways they compete for space and sunlight. Are there some plants that seem to grow together without competing or cooperating with each other? Do garden plants look as healthy when lots of weeds grow around them?

In a garden, we can see an example of crop plants and humans working together for the benefit of both. The plants provide food for us (or for our animals) and beauty, and we provide care for the plants so that they can complete their life cycles. We can also see in the garden the competitive relationship. Weeds compete with garden plants for root space and water in the soil, for sunlight, and for soil nutrients.

Where do people fit into these natural systems? Is humankind a part of nature or separate from it? Do the actions of people improve nature or hinder it or make no difference? Our environment supports us and makes life possible for people and other animals. Sometimes we take this for granted, dumping industrial by-products and city garbage into the air and water, hoping it will all just go away. The most important lesson to learn is that we can all individually contribute to either improving or degrading our environment. It is a personal responsibility. Everything is connected to everything else, including us. We must realize, too, that plants and animals have a right to be here other than to serve humans. The world would be an unpleasant place without them.

Granting Deeds

By giving children an imaginary deed to a piece of land, they can use their imaginations to consider alternative uses and to realize that all of our worlds are connected and interdependent. Divide the group into teams of two or three and go to a large park. Give each group an imaginary deed to one part of the land and give them the following charges: decide how you want to make your own world. Start by describing the world around you, list all the things around you such as houses, roads and plants. Think about what you would need to survive. What would you want to bring in and what would you take away? What would be the most important thing to do first? Develop a plan and show where and how you would like to live. Use sketches to show the changes you would make to live here. How would you make it fun to live here? Would you make it beautiful?

Have them list the ingredients of their worlds, then have them draw a picture of it. Come together again and decide if the imaginary worlds will maintain themselves year after year. Have they chosen representatives of the food cycle: plant-eaters, plants, and decomposers? How about subtle factors like soil and climate?

Exploring city environments with children will give rise to questions that may cause them to appreciate what previously had been taken for granted. Respect for life of all kinds depends upon knowing it in all its forms and making connections between ourselves and the world around us.

Our highly specialized, technological society does not foster holistic world views among its inhabitants. Keeping in mind that cities hold 80 percent of our human population and that we are continually losing natural areas and resources, it is increasingly important to nurture respect for nature.

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National Resources

Alan R. Sandler, Environmental Education
The American Institute of Architects
1735 New York Avenue NW
Washington, D.C. 20006-5292

The American Nature Study Society
John A. Gustafson
R.D. 1, Box 195
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Minding The Earth (tapes and study guides)
The Strong Center
2355 Hearst Avenue
Berkeley, CA 94709
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7100 Connecticut Avenue
Washington, D.C. 20015

USING PLANTS TO HELP CHILDREN LEARN ENGLISH

Dorothy W. Purdy

As soon as you hear the names, Bang Do, Nynke Feith, Toshimasa Nabeshima, Elia Silvestre, you know. They are different. They are new to our country. From Laos, Germany, Japan, Portugal, Mexico, Peru, to name but a few. These children have found their way to White Plains, New York. They are fifth and sixth graders enrolled in a special program designated E.S.O.L. or "English to Speakers of Other Languages." They have come because their parents believe that America is a better choice. Many speak only their native language such as Spanish, Japanese, or Portuguese. Others speak a few words of stilted English.

Taking a risk and daring to "do it different," teacher Ethel Kanofogel and her District Coordinator, Sue Gilligan, from the White Plains School District, decided to try a new approach to help these children learn English. Aware of the program for Independent Study in Botany for Gifted Students at the Research Center of the Brooklyn Botanic Garden in Ossining, New York, they proposed a new idea. Would it be possible to have a program to help children speak English by using plants as the vehicle for learning?

In 1982 a pilot program, under my direction as Coordinator and teacher at the Research Center, was begun. The plan was to have the children (twelve) come to the Research Center for a two-hour period for five sessions spread over four months. Each session would expose the children to a new experience with plants in addition to building on the experience of the previous one.

Coming from their city environment, the ride to the Research Center is a study in contrasts. From city buildings and sidewalks, the scene changes to open fields and wooded lots. The fieldstone building of the Research Center with its attached greenhouses is located on 226 acres of wooded and grassy terrain of special country beauty. You can see the excitement this trip has brought as the children get off the bus and file into the large, sunny classroom. Whispers in Spanish and Japanese are heard and a definite feeling of anticipation and excitement is in the air.

What of the experience? Did it make a difference? A resounding "yes!" The plants made the impact. Plants from all over the world are grown in the greenhouses at the Research Center—columneas, marantas, and peperomias from the tropics. Squeals of delight could be heard as a child recognized a plant he or she once saw growing in the backyards of Mexico, Brazil, or Portugal. The desire to communicate becomes intense. Perhaps it is good that Mrs. Purdy speaks only English for the children have to try to tell the story of that plant in "their" country!

The two-hour sessions involved listening to instructions, writing in a record book, and actually handling the materials, whether they be the plants or microscopes. The topics were as varied as the "Propagation of Herbs" to the examination of "Tradescantia under the Microscope." The children were stimulated in so many ways. Many had never seen microscopes, greenhouses, or misting benches. Few had ever seen "real" scientists in white lab coats. Children who were initially so shy began to smile and whisper. Soon voices clamored to be heard and the desire to learn was evident.

Mrs. Kanofogel and Miss Gilligan report astounding success. Children who tested poorly because they were afraid to respond have gained confidence in their ability to learn. Changes became apparent not only in their reading classes but in math as well.

At the end of the five sessions the children make a formal presentation using their carefully kept data and tenderly cared-for plants to demonstrate their learning. To see their faces filled with pride as they described cells magnified 100× under a compound microscope or the special techniques they used for propagating a *Streptocarpus* or *Rosmarinus officinalis* is enough to justify the program.

Additional Information, Books, and Resource Materials

General Information/Instruction

Consult your local cooperative extension agent for circulars on all aspects of gardening. Many have materials for 4-H programs that are of practical interest to children, youths, teachers, and program directors.

Other sources include:

Cornell Cooperative Extension Publications, Distribution Center C, 7 Research Park, Cornell University, Ithaca, NY 14850.

Cooperative Extension Service, The Ohio State University, Columbus, Ohio 43210

"Mrs. G. Arden's Green Scene," designed for the beginning gardener. 4-H Circular #690

University of California Cooperative Extension, Common Ground Garden Program. "Children's Gardens: A Field Guide For Teachers, Parents & Volunteers" by Elizabeth Bremmer and John Pusey.

Project Life Lab, 966 Bostwick Lane, Santa Cruz, CA 95062. Curriculum prepared for teachers to develop a garden-based science and nutrition program. It includes three books: "The Growing Classroom," "Becoming A Farmer," "Science and Nutrition."

Most arboreta and botanic gardens have gardening and related programs for children. Consult them for classes, library resources and printed material.

Books In-Print

Children & Gardens, Gertrude Jekyll. (A reprint of the 1908 edition) Published by Antique Collectors' Club, Suffolk, England. 1982.

Gardens Shown to the Children, Jane H. Kelman. R-West. 1978.

Gardening with Children, Thomas Dunks. Harvest Books.

Mr. Bumba Plants a Garden, Pearl A. Harwood. Lerner-Pubns. 1964.

Gardening with Children, Alison Ross. Faber & Faber

To order the following books, please write directly to the publisher; GARDENS FOR ALL/The National Association for Gardening at 180 Flynn Avenue, Burlington, VT 05401: *The Community Garden Book*, Larry Sommers. *The Youth Gardening Book*, Lynn Ocone. *Your Nutritious Garden*, Dick Raymond & Gardens for All. *Tools & Techniques For Easier Gardening*, edited by Lynn Ocone and George Thabault.

Company Offerings

Many companies offer products/kits/books that help promote a child's interest in gardening. Some of these include:

Clyde Robin Seed Company
P.O. Box 2366
Castro Valley, CA 94545
"A Child's Garden" kit (a can filled with seeds, planting stakes, book)

Smith & Hawken
25 Corte Madera
Mill Valley, CA 94941
Children's-scale gardening tools

AN INVITATION TO JOIN AND ENJOY

A man does not plant a tree for himself;
he plants it for posterity.
—Alexander Smith

ALL who read these lines and are interested in the out-of-doors and the beauty of living things are cordially invited to become Members of the Brooklyn Botanic Garden. The dues are $15 annually. Memberships make fine gifts, too. For many, the Botanic Garden means spiritual enrichment, and they find satisfaction in contributing toward its support. Others enjoy the Membership opportunities, which include a subscription to PLANTS & GARDENS, occasional plant and seed "dividends," popular short courses at reduced rates and other benefits. Why not get pleasure from both?

cut off here

APPLICATION FORM FOR MEMBERSHIP

BROOKLYN BOTANIC GARDEN (A Membership Society)
1000 Washington Avenue, Brooklyn, N.Y. 11225

I would like to become a member of the Brooklyn Botanic Garden

Mr./Mrs./Miss/Ms

Address

City State ZIP

Membership Categories. Please write to the Garden for details of special memberships.

Individual Membership, $15 Sustaining Membership, $25

Supporting, $100 Contributing, $250 Patron, $500 Benefactor, $1000

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PLANTS & GARDENS

BROOKLYN BOTANIC GARDEN RECORD

Vol. 40 No. 4 Winter 1984–85

THE YEAR'S HIGHLIGHTS

In Gardening and Horticulture

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[illegible]

Wildflowers [illegible]
Easy-Care Landscaping, [illegible]
Recent [illegible]

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PLANTS & GARDENS

BROOKLYN BOTANIC GARDEN RECORD

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Cover photo, *White Violets,* by Gottscho-Schleisner

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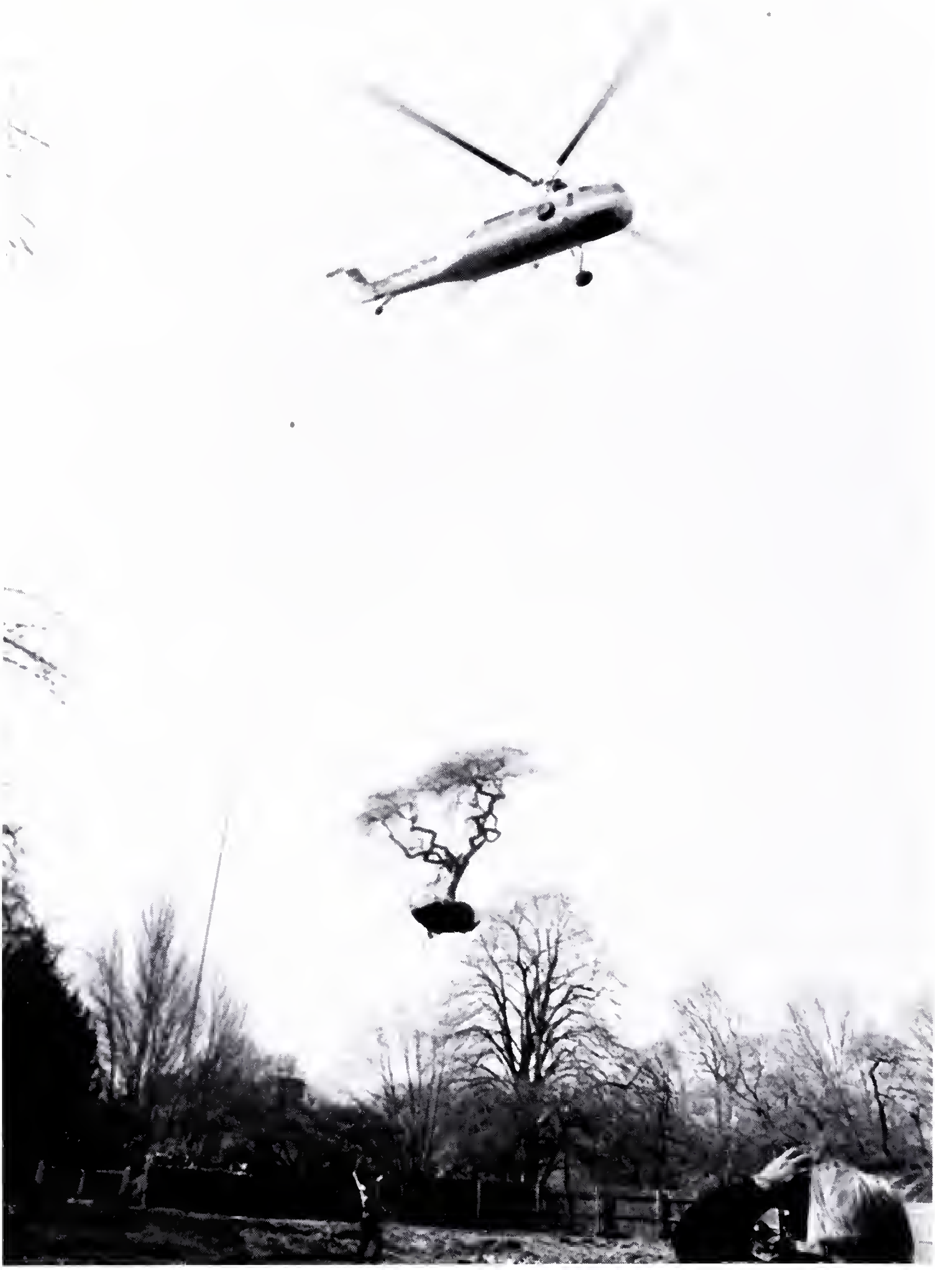


Herbert Newlin

A tree flew across Brooklyn Botanic Garden on April 3, 1984. The 50-year-old 'Red Jade' crabapple, developed at the Garden in the 1930s and patented in 1951, was growing in the construction site for the Garden's $20 million new Conservatory complex. The crabapple, the original from which thousands of offspring have been propagated, weighs approximately 3 tons and is about 18 feet high and 18 feet wide—too big and heavy to be moved by more conventional means.

LETTER FROM THE BROOKLYN BOTANIC GARDEN

The tradition of forty years is being followed once again. Within these pages readers will find an assortment of articles that have appeared in various publications during 1984. This is a chance to read articles that might have been missed and that we feel have merit. Our thanks to the numerous publications and authors for sharing their articles with us.

"The fact is, it's a trendy country, and gardening like any other field has its share of 'in' plants and 'out' plants," to quote from Fred McGourty's article on page 26. These trends are to be found often within these pages, and not only plants but general trends in gardening.

There seems to be a definite movement toward less labor-intensive gardening. Some gardeners are turning lawns into meadows, planted with wildflowers or ground covers; the use of mulches to reduce weeding and watering and that also have eye appeal. There is also more interest in planting disease-resistant varieties.

Plant explorers add new plant introductions. Plant breeders are hybridizing more disease-resistant varieties—there are now a number of American elms available to the homeowner. Although these elms may be difficult to find, demand will eventually make them more available.

Again this year there have been a great number of gardening books from England; though many are highly readable and informative, in most cases the usual transatlantic adjustments must be made before applying to the garden stateside. We have included a provocative article on the philosophy of garden books by Noel Perrin.

As the new gardening season swings into gear, it is always rewarding to reflect back over what has happened in the past year.

May your gardening year be a good one.

Barbara B. Pesch
Editor

BBG's
GERTRUDE JEKYLL LETTERS

Exchanging greetings, information, mild complaints, perhaps a bit of gossip—personal letters share a similar form but never the same content, especially when they are written by someone such as Gertrude Jekyll who was renowned for her originality and vigorous personality. Soon after the publication in America of two of her books, *Wall and Water Gardens* (1901) and *Roses for English Gardens* (1902; co-authored with Edward Mawley), Miss Jekyll began a warm correspondence with Mrs. Alice Earle (later Hyde), an early benefactor of BBG and herself an author of books on American social history and gardens. BBG, through the curatorial efforts of Brenda Weisman, Director of Information Services, has released two of these letters for publication. The letters were part of a 1917 donation to BBG and its newly established library that included 150 volumes of garden and garden-related books, the largest gift of its kind that year.

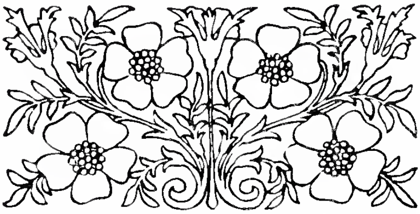
Miss Jekyll (1843–1932) was trained as an artist, but failing eyesight in her late forties compelled her to turn to professional garden consultation and planning. Although she began her second career rather late in life, she had been a keen and highly skilled and observant gardener for many years and brought this expertise to her consultations. Her subsequent success approaches legend.

The resurgence of interest in Miss Jekyll and her work and influence has resulted in the republication of a number of her books, including the ones mentioned above, as well as Jane Brown's *Gardens of a Golden Afternoon* (Van Nostrand Reinhold, 1982), an account of Miss Jekyll's collaboration with Edwin Lutyens, the young architect who provided the elegant physical structures for her splendid gardens.

The year these letters were written was also the year that Miss Jekyll's book, *Old West Surrey,* appeared. Her lament to Mrs. Earle for a proper staghorn-handled knife is a continuation of the concern that she expressed in her book about the supplanting of old and handsome utilitarian objects and furniture with inferior, non-indigenous articles.

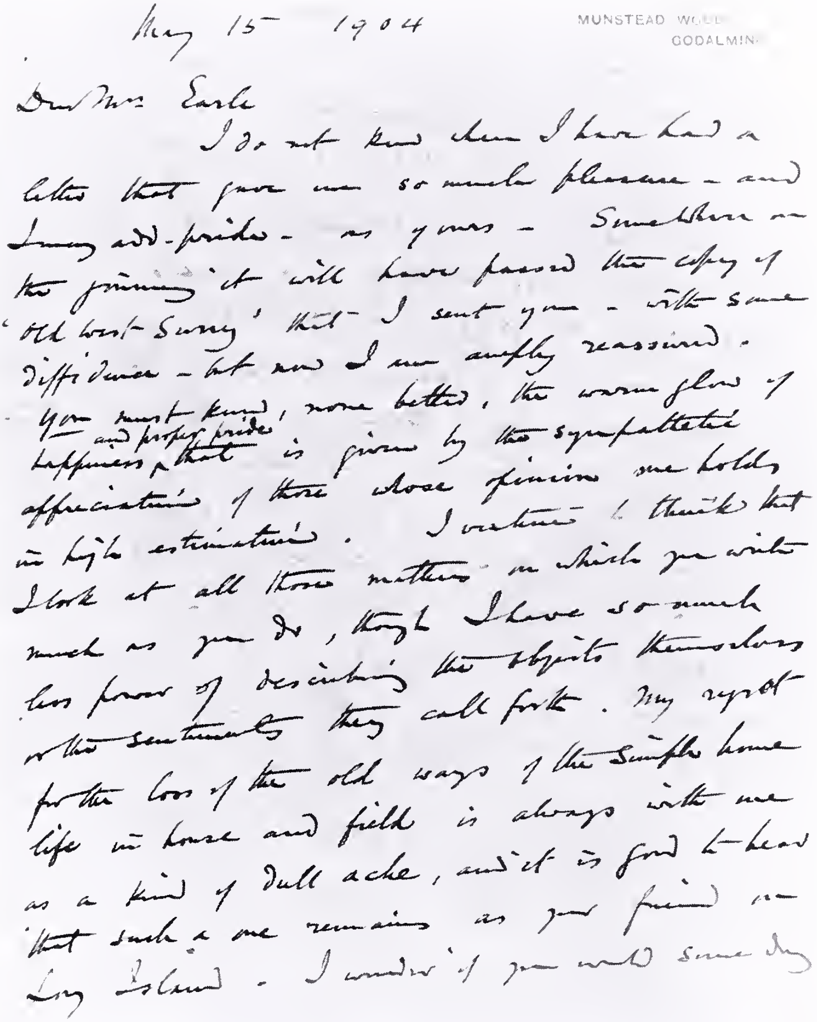
The letters reproduced below include a transliteration, as Miss Jekyll's writing can be as indecipherable as her prose is lucid.

—*Margaret Joyner*



Title page decoration, Roses for English Gardens

Letters © BBG



May 15 1904

MUNSTEAD WO
GODALMIN

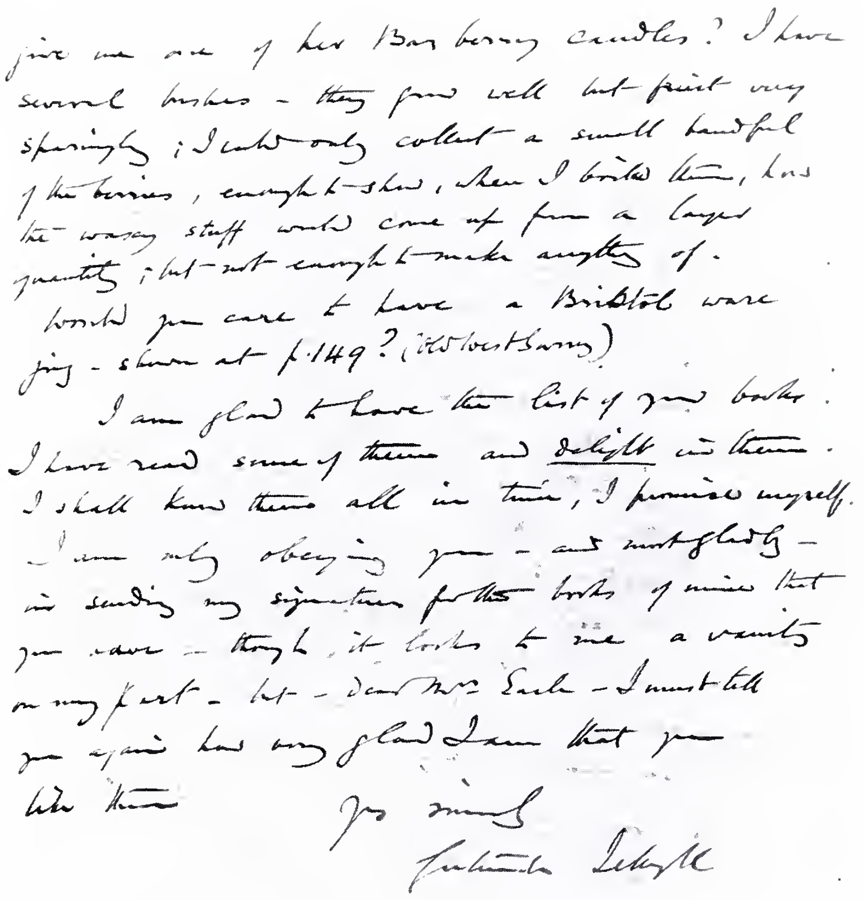
Dear Mrs Earle

I do not know when I have had a letter that gave me so much pleasure – and I may add – pride – as yours – Somewhere in the journey it will have passed the copy of 'Old West Surry' that I sent you – with some diffidence – but now I am amply reassured. You must know, none better, the warm glow of happiness and proper pride that is given by the sympathetic appreciation of those whose opinion one holds in high estimation. I venture to think that I look at all those matters on which you write much as you do, though I have so much less power of describing the objects themselves or the sentiments they call forth. My regret for the loss of the old ways of the simple home life in house and field is always with me as a kind of dull ache, and it is good to hear that such a one remains as your friend on Long Island. I wonder if you would some day

Munstead Wood, Godalming.
May 15, 1904

Dear Mrs. Earle—

I do not know when I have had a letter that gave me so much pleasure—and I may add—pride—as yours. Somewhere in the journey it will have passed the copy of 'Old West Surry' [sic] that I sent you—with some diffidence but now I am amply reassured. *You* must know, none better, the warm glow of happiness and proper pride that is given by the sympathetic appreciation of those whose opinion one holds in high estimation. I venture to think that I look at all those matters on which you write much as you do, though I have so much less power of describing the objects themselves or the sentiments they call forth. My regret for the loss of the old ways of the simple home life in house and field is always with me as a kind of dull ache and it is good to hear that such a one remains as your friend on Long Island. I wonder if



give me one of her Bay berry candles? I have several bushes - they grow well but fruit very sparingly; I could only collect a small handful of the berries, enough to show, when I boiled them, how the waxy stuff would come up from a larger quantity; but not enough to make anything of.

Would you care to have a Bristol ware jug - shown at p. 149? (Old West Surry)

I am glad to have the list of your books. I have read some of them and delight in them. I shall know them all in time, I promise myself. I am only obeying you - and most gladly - in sending my signature for U.S. books of mine that you have - though it looks to me a vanity on my part - but - Dear Mrs Earle - I must tell you again how very glad I am that you like them

Yrs sincerely
Gertrude Jekyll

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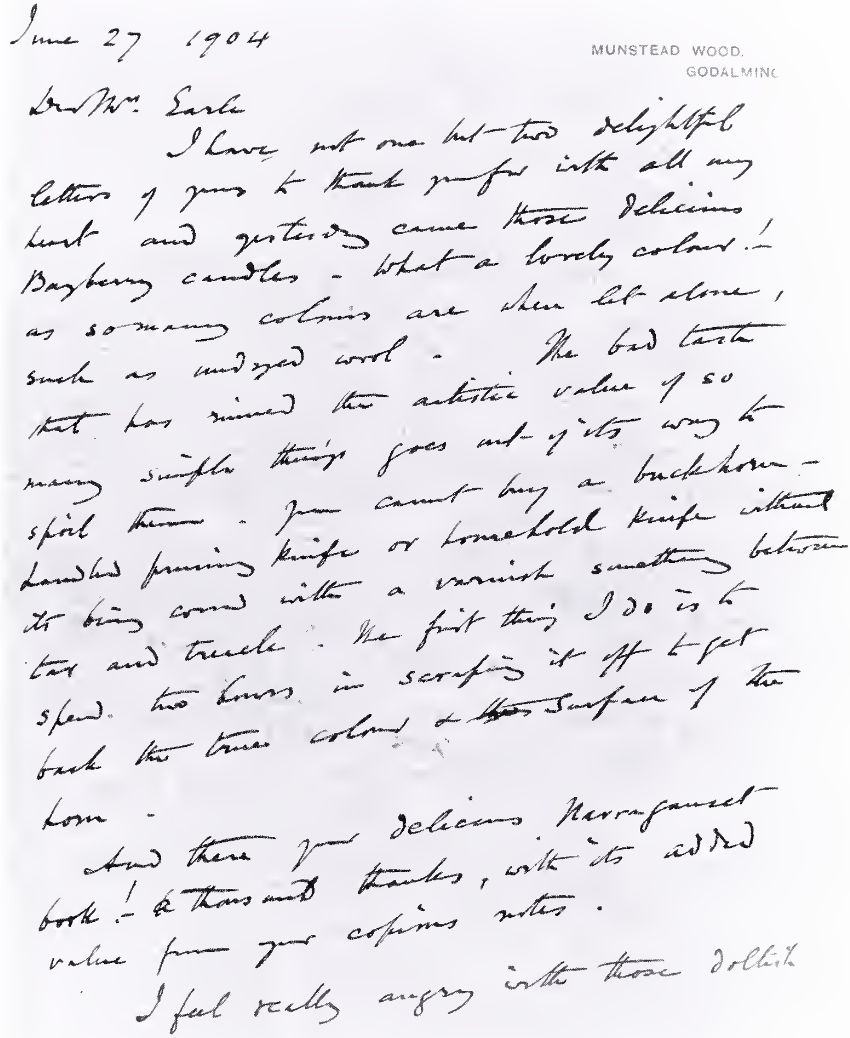

June 27 1904

MUNSTEAD WOOD.
GODALMING

Dear Mrs Earle

I have not one but two delightful letters of yours to thank you for with all my heart and yesterday came those delicious Bayberry candles - What a lovely colour! - as so many colours are when let alone, such as undyed wool - The bad taste that has ruined the artistic value of so many simple things goes out of its way to spoil them - You cannot buy a buckhorn-handled pruning knife or household knife without its being covered with a varnish something between tar and treacle - The first thing I do is to spend two hours in scraping it off to get back the true colour & ~~the~~ surface of the horn -

And then your delicious Narragansett book! - a thousand thanks, with its added value from your copious notes.

I feel really angry with those doltish

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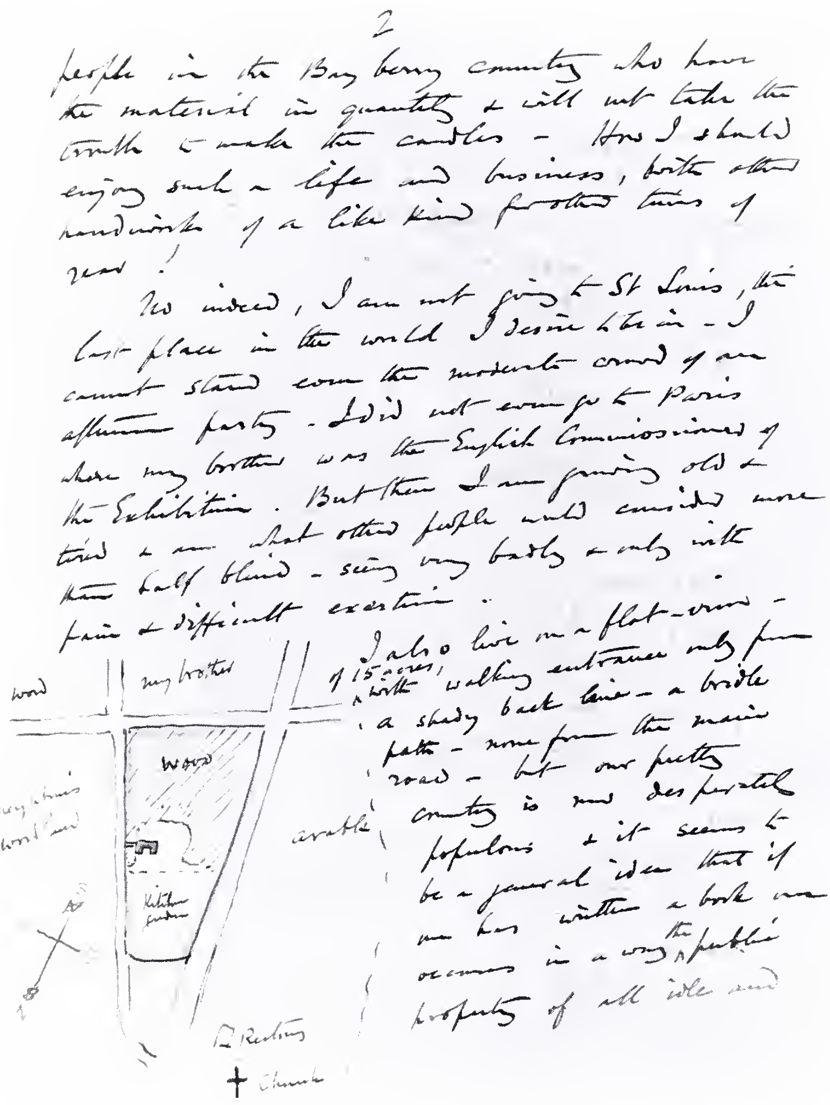

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people in the Bayberry country who have the material in quantity & will not take the trouble to make the candles – How I should enjoy such a life and business, with other handiwork of a like kind for other times of year!

No indeed, I am not going to St Louis, the last place in the world I desire to be in – I cannot stand even the moderate crowd of an afternoon party – I did not even go to Paris where my brother was the English Commissioner of the Exhibition. But then I am growing old & tired & am what other people would consider more than half blind – seeing very badly & only with pain & difficult exertion.

I also live in a flat-iron of 15 acres, with walking entrance only from a shady back lane – a bridle path – none from the main road – but our pretty country is now desperately populous & it seems to be a general idea that if one has written a book one becomes in a way the public property of all idle and

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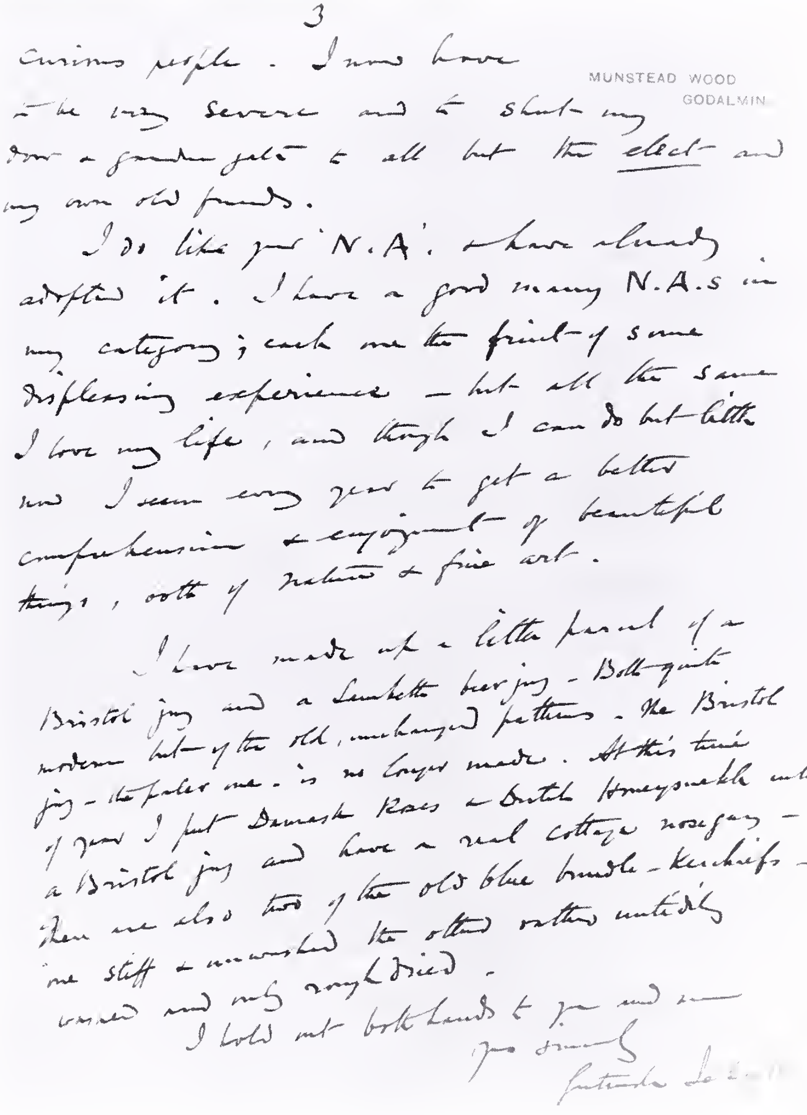

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MUNSTEAD WOOD
GODALMIN

curious people. I now have to be very severe and to shut my door & garden gate to all but the elect and my own old friends.

I do like your 'N.A.' & have already adopted it. I have a good many N.A.s in my category; each one the fruit of some displeasing experience – but all the same I love my life, and though I can do but little now I seem every year to get a better comprehension & enjoyment of beautiful things, both of nature & fine art.

I have made up a little parcel of a Bristol jug and a Lambeth beer jug – Both quite modern but of the old, unchanged patterns. The Bristol jug – the paler one – is no longer made. At this time of year I put Damask Roses & Dutch Honeysuckle into a Bristol jug and have a real cottage nosegay – There are also two of the old blue bundle-kerchiefs – one stiff & unwashed the other rather untidily washed and only rough dried.

I hold out both hands to you and am

Yours sincerely

Gertrude Je

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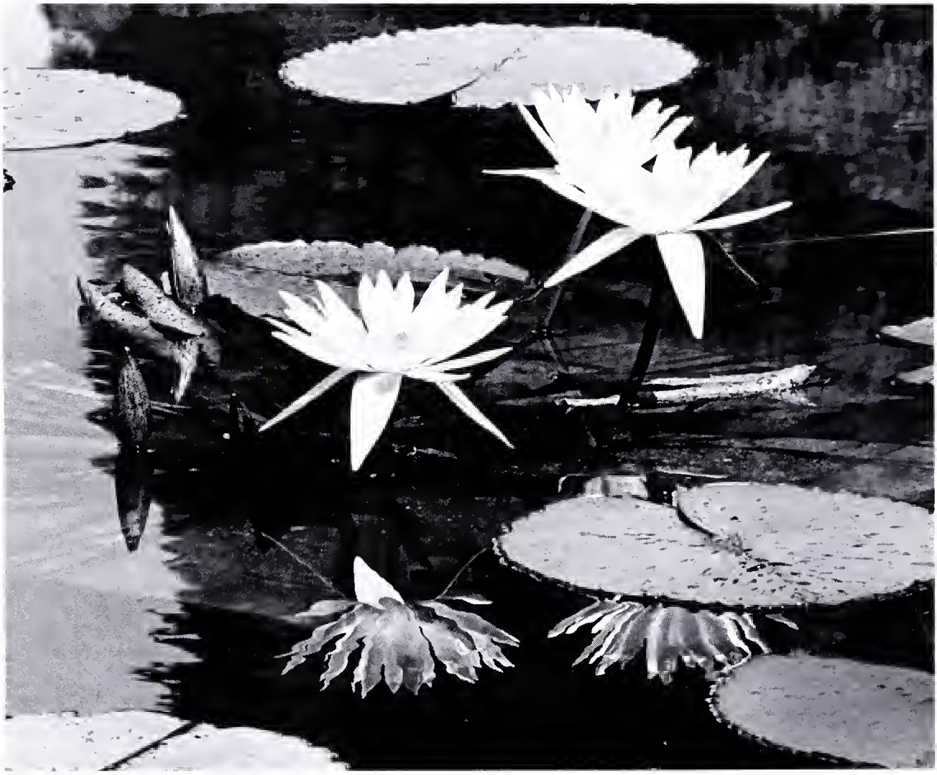

Missouri Botanical Garden

Water lilies at Missouri Botanical Garden

AUTUMN IN THE GARDEN

Henry Mitchell

Gardeners rarely see mists in the American fall, and some of us never notice that mellow fruitfulness the poet promises, but in much of the country this is the finest of the seasons for good weather, and certainly the busiest, since almost everything wants to be protected or comforted now, including the distraught gardener.

A pity, a real pity, to waste the gorgeous season in drudgery. The sensible gardener will allocate spring for dashing about in a panic to get things done. Summer is sacred to complaining that things have not turned out as hoped (though pretty much as expected, perhaps), and winter is the season of dreaming. This leaves the fall for wandering about the garden idly, or serenely. Much should be done, but who needs to read about it when the evidence abounds just outside the door? Without falling into that tedious habit of warning us all of things

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Reprinted from "Garden Book Club Bulletin," October 1984.

that must be done instantly, I might gingerly remind us all how cold and unattractive mud is in the spring, and how tenaciously everything from bluegrass to Bermuda grass to dock resists being pulled up in spring. The winter may have been awful, but it's a rare weed that hasn't made hay through the cold season so that by spring it can't be gently tugged but must be excavated.

Weeds know vacation dates and triple their growth rate during them. They will not yield to a gentle tug in the fall any more than the spring, but at least the ground is not soggy and the sky is usually a grand blue.

Surely everybody knows the bugbane, *Cimicifuga* (to turn to happier thoughts than weeds). This is one of those few plants that bloom well in fairly heavy shade, and that (unlike some of those wild flowers that people collect) you can actually see several feet off when it blooms. The spikes reach waist to chest height, slender wands packed with small white florets. The stems are wiry and strong; they almost never need staking unless you live at the edge of a windy cliff—few stalks curve more handsomely. A good clump of bugbane is a far greater treasure than is commonly known, except by gardeners who have discovered its elegance.

The white Japanese anemone is equally a standby for early fall, blooming for weeks on end in a modest way, but if grown in the open it needs staking. I have seen it held up, a great patch of it along a wall, in a cat's cradle of black thread, to keep it from leaning too far away from the wall toward the light. Mine grows in full sun and is sufficiently happy that it grows too tall (five feet) and goes down in the first heavy wind. Its vigor may be less this year at my place, thanks to the Welsh terrier that favors this plant above all others for retreating to after a bath. Back and forth, back and forth.

Maybe the most wonderful thing about the fall is the tropical water lilies. They do not, of course, understand winter, and if the fall is mild and frost-free, even though the nights have become chilly or cold, they sometimes continue to flower even past Thanksgiving.

With me, they usually stop at the end of October, but while they last they are highly improbable creatures in the garden, vastly overdressed, as you might say, for their surroundings.

Colored leaves are an autumnal glory for most of the continent, but this is unfair to the gardener in a way. If every field and ditch and scrub woodland is in glory, the gardener achieves little by trying to improve on wild nature. The red maples, sour and sweet gums, hickories and oaks, and all the rest can be astonishing at their best—it depends on the weather—and there is no point searching the world for something new.

In the small gardens that most of us have nowadays there is not much sense planning for fall coloration of the leaves. But when the choice comes between a small crabapple and a dogwood, the dogwood may well win on the basis of his handsomer foliage, gorgeous crimson leaves, and scarlet fruit. And in choosing azaleas, it is no crime to choose one (like the scarlet 'Stewartstonian') that has bronzy-red leaves in fall and winter. While fall coloring is too fleeting to justify making much of it in a small place, still it is worth thinking about (when other things are equal) choosing the one that gives the little bonus of brightness in October and November.

Dwarf Japanese maples, for example, vary a good bit. I have one that only begins to color after Thanksgiving. Many years the weather becomes too cold, and it drops its leaves in December without having shown much color at all. But about every other year the weather is kind, and it is a great joy to have this small shrub come into glory in late November when other things have called it a day.

Certain sumacs, weedy in themselves and hardly deserving a place in the small garden, color early in September and (in moderation) may find a spot they would not otherwise be entitled to if you happen to long for an early burst of scarlet.

But apart from any specific plants—some gardeners prefer dahlias to bugbanes, after all—the glory of the fall is in the air, the light, the squirrels, the pace of the year. Or, less grandly, the weeds have slowed down. Above ground, at least. ◆

Photos by Ann Silvi

Deciduous woodland. Local Flora Section, BBG

THE GARDEN OF EARTHLY DELIGHTS

John Hanson Mitchell

A few years ago, I used to regularly go for tea with a woman named Megan Lewis who tended a notoriously unkempt garden in the Berkshire region. Mrs. Lewis, who was about seventy at the time, was not the type of woman who would slop about in slacks or jeans. Even when she was at work in her garden, she wore expensive shirt-waist dresses and fixed her long gray hair in a French twist. She loved wildflowers, birds, the finest English teas and, for awhile (when it was thoroughly illegal), used to drink smuggled Canadian whiskey with gentlemen friends. That ended when Prohibition ended and she retired with a husband, and later a family, to grow flowers in the hills of the Berkshires.

In those early years she worked and reworked the old dooryard gardens of the farmhouse. She began, she said, with a formal garden such as you would see in the gardening books and magazines of that era, setting out in an orderly fashion beds of tulips and planting a classical English country garden of hollyhocks and delphiniums along the fencerows and stone walls. But after some twenty years of this, she grew bored of all the splendor of her creation and began taking long walks in the nearby woodlands. The change had something to do with approaching old age, she used to say, a sort of winding down, or winding up.

In the Berkshire forests she began to notice the more subtle beauties of the landscape, the quieter, less raucous, wildflowers and shrubs. She began, as many do, by bringing these wildlings home and planting them alongside her nursery-purchased darlings. But, in time—in time being some ten years for Megan Lewis—she began to sense that something was wrong with the idea of stealing flowers and shrubs from the forest landscape to decorate her own habitat. She languished for a full season one year, stopped gardening altogether, and then, suddenly, saw what she had to do. "From that point on,"

Reprinted with permission from "Sanctuary," the publication of Massachusetts Audubon Society, April, 1984.

she told me, "I followed nature's one dictum. I left things alone."

Her only gardening tools now are pruning shears, a scythe, and a lawn mower. Instead of planting beds of ferns and hard-to-transplant wildflowers, she has allowed them to come to her. She mows paths around her rampant former lawn, trims here and there with her pruning shears to maintain the shape of the arrowwoods and the honeysuckles, and allows her former enemy, the wild cucumber, to ramble over the hedge that for twenty years she so cherished. The white farmhouse is still trim, and beyond her stone terrace there is what she calls her sole concession to the dictatorship of the English—a small lawn with a tea table and wrought-iron furniture from the 1920s.

Here, on Sunday afternoons from May through November, Megan Lewis entertains her visitors with tea and lengthy anecdotes. Beyond the terrace, amid the tangle of hedges and the young sprouts of maples and beech, cardinals and warblers trill and buzz, squirrels and chipmunks forage, and an entire unseen ecosystem of snakes, toads, frogs, beetles, spiders, slugs, and all the other elements of a healthy environment "live and dwell," as Mrs. Lewis would phrase it "and have their being." ❦

In the foreground, wet area sedges and arrowhead; behind, a black cherry (*Prunus serotina*). All are plants that come in to appropriate environments when people decline to arrange nature.

The bane of vampires, it has some powers that might keep the doctor away, too. . .

GARLIC—NEVER CEASING TO SURPRISE

Jane E. Brody

Vitamin C enthusiasts, move over. Garlic may be at least as effective as your chosen nostrum in warding off the common cold. People throughout the world have used it for years as a "blood cleanser" and cold preventive.

At the very least, if you eat plenty of garlic every day, it should keep people who carry cold viruses at enough of a distance to prevent you from catching their infections.

More seriously, recent scientific evidence indicates that garlic is far more than an herbalist's pipe dream. It is not just a case of "If something smells so bad, it surely must be good for you." The studies show that garlic may have distinctive health benefits, including protective value against heart disease, stroke, cancer, and diabetes, as well as antibiotic properties.

Medicinal Properties

Needless to say, garlic's health potential did not escape the notice of herbalists and physicians for thousands of years. The Codex Ebers, an Egyptian papyrus from around 1550 B.C., suggested twenty-two garlic-based remedies for ailments ranging from body weakness and headaches to tumors of the throat. Pliny the Elder, the Roman naturalist, touted garlic for sixty-one different maladies, from hoarseness and hemorrhoids to epilepsy and tuberculosis; Hippocrates, the father of medicine, used it as a laxative and diuretic; Aristotle recommended it as a cure for rabies; Mohammed used it to treat scorpion stings, and the Greek physician Galen dubbed it the common folk's "heal-all."

It was noted that the garlic-eating French priests who attended victims of the plague during an 18th-century outbreak in London remained healthy, while the English priests, who shunned the odoriferous herb, caught it readily. But by World War I, the British had caught on and used garlic to control infection, while German soldiers used it to prevent gangrene in battle wounds. Garlic is popularly used to prevent and treat traveler's diarrhea, and indeed a 1969 study showed garlic to be deadly to bacteria commonly associated with this condition.

Folk wisdom has long hailed garlic as a powerful protector against evil spirits. Sue Kreitzman, author of "Garlic," a folklore-laced cookbook published last summer by Harmony Books, notes that in the Middle Ages, cradles were garlanded with braids of garlic to keep fairies from stealing babies, and that some Chinese, Greek, and Jewish grandmothers still present cloves of garlic to new babies to ward off the "evil eye." Most infamous is garlic's reputed

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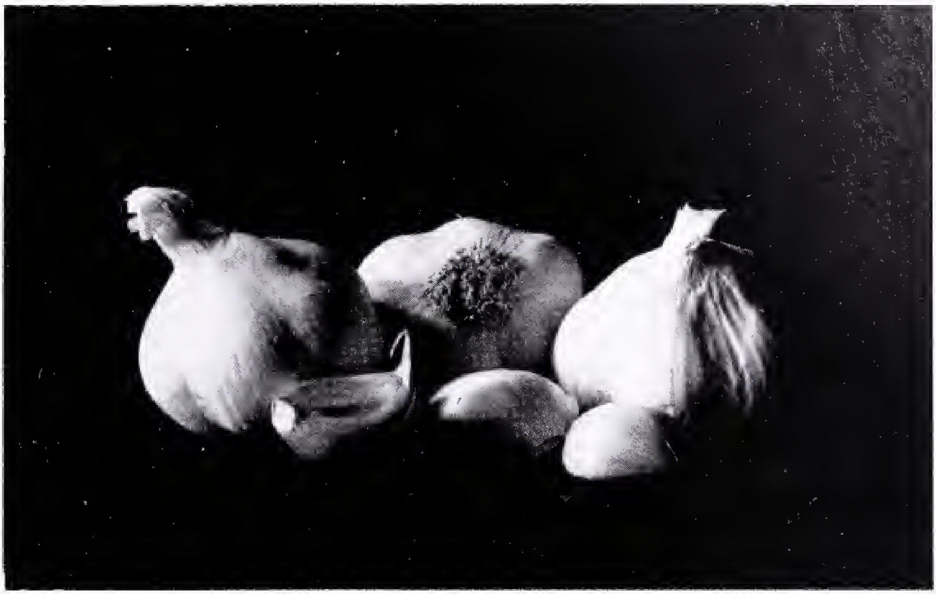


M. Joyner

Garlic (*Allium sativum*)—bane or blessing?

power against vampires: to keep these bloodthirsty creatures from your jugular, cover all doors and windows with clusters of garlic and wear some around you neck.

Speculation about garlic's pesticidal properties has long infused gardening literature. As Robert West Howard reported in the newsletter Gardens for All News last January, "The garlic cloves I planted abaft our nasturtiums, roses, squash, and beans seemed to guarantee freedom from aphids, leaf beetles, cutworms, and other chawing varmints." And an Agriculture Department document portrayed garlic oil in 1982 as a "relatively safe pesticide" with the ability to destroy aphids, cabbage butterfly caterpillars, Colorado beetle, and mosquito larvae. Some even say that eating lots of garlic is an effective mosquito repellent.

Culinary Surprises

Botanically and gastronomically, garlic is the king of Mediterranean and Asian herbs. It has been cultivated in China since time immemorial. It was mentioned in Sanskrit, one of the first written languages, as a staple in the diet of the ancient Sumerians. It was consumed daily by the Egyptian laborers who built the Pyramids, and it was even found in the tomb of King Tutankhamen.

The botanical name for garlic, *Allium sativum*, was probably derived from the Celtic word "all," meaning hot or burning. Its aromatic properties are directly attributable to an amino acid called alliin found in garlic oil. Alliin has no distinctive odor, but when a clove of garlic is sliced or bruised, damage to cell membranes allows alliin to come into contact with an enzyme that converts it to allicin, the potent chemical we readily identify with garlic odor. In cooking, you can control the amount of allicin produced by how little or much you cut the garlic: a whole clove unpeeled or gently peeled after parboiling gives off little or none of this chemical; bruising or slicing a clove produces some, but mincing or pressing it releases the maximum allicin.

Long, slow cooking destroys allicin, resulting in a rather tame vegetable instead of a pungent herb. This why certain soups and stews can be prepared with twenty to forty cloves of garlic and not be inedible.

After forty-clove garlic chicken is cooked for an hour and a half, for example, the whole cloves are mellow and almost sweet, and are delicious smeared on crusty bread. It is true, however, that consumption of raw or minimally cooked garlic can result in a distinctive reek, not just from one's breath but also from every pore in the body.

Cardiological Effects

But why eat whole cloves of garlic, or any garlic at all? For one reason, it may help to prevent heart disease. In countries where garlic is consumed generously and regularly, the incidence of heart disease is very low. This observation, according to recent findings, may be more than coincidental. Garlic can help to lower blood levels of cholesterol, the waxy substance produced by all animals that is a chief culprit in coronary heart disease in modern Americans.

In a study conducted by Dr. Arun Bordia at Tagore Medical College in India, twenty healthy people were fed garlic oil for six months. Serum cholesterol levels dropped an average of 17 percent and triglycerides, another heart-damaging blood fat, dropped by 20 percent during garlic administration. In addition, the garlic diet was associated with an increase in a protective blood substance known as high-density lipoproteins (HDL's), and a decrease in their heart-damaging counterparts, low-density lipoproteins (LDL's).

In a second part of the study, sixty-two heart patients were divided into two groups and one got the garlic treatment for eight months. In the treated group, but not in the other, serum cholesterol and triglycerides dropped significantly and HDL's rose, while LDL's dropped. The net result of such a change in blood fats would be a reduced risk of heart attack.

Animal researchers at the Wistar Institute in Philadelphia and at the University of Wisconsin showed that garlic oil in the feed significantly reduced cholesterol levels in rabbits, chickens, and rats. Even more significant, it dramatically reduced the accumulation of cholesterol in the rabbits' arteries.

Previous studies by the Indian researcher and his colleagues, and by a research team in Washington led by Dr. J. Martyn Bailey showed that garlic oil can inhibit clot formation, which in turn would reduce the risk of heart attack and stroke. In another study the team, headed by Dr. Amar N. Makheja of the George Washington University School of Medicine, isolated a substance from both garlic and onions that keeps blood platelets from sticking together. The clumping of these cells is a crucial step in the formation of blood clots. A substance other than allicin seems to be responsible for this property, so it may be possible in this case to separate the benefit from the stench.

In both China and Japan, garlic has been used for centuries in the treatment of high blood pressure, and the Japanese food and drug administration has approved garlic therapy for this purpose.

Other Medicinal Properties

At the United States Department of Agriculture, Dr. Mei Ling Chang and Margaret Johnson showed that garlic can also reduce blood sugar levels and raise the amount of insulin in the blood, which may prove beneficial to diabetics. In one study in rabbits, garlic juice was shown to be almost as effective as the drug tolbutamide in lowering blood sugar.

Possible anticancer activity of garlic has been noted in several animal studies, variously attributed to the enzyme allinase and the trace metals germanium and selenium, all of which are found in garlic.

But far clearer are garlic's antibiotic properties. At the Medical College of Virginia, a water extract of garlic was shown to inhibit growth of a fungus that causes a form of meningitis throughout the world. At the University of Indiana, Dr. Michael Tansey, who also studied a water extract, showed that garlic could slow or stop the growth of various fungi and molds, including *Candida albicans*, a yeast that commonly causes vaginitis, and *Histoplasma capsulatum*, a fungus carried by dust that causes a disease similar to tuberculosis, as well as fungi that cause athlete's foot and ringworm.

A 20–Clove Soup

The following recipe, which calls for 20 cloves of garlic, is from **The Victory Garden Cookbook,** by Marian Morash (Knopf, 1982).

Garlic Piperade Soup

20 garlic cloves
2 cups sliced onions
1 cup sliced peppers
3 tablespoons oil
3 cups peeled, seeded and sliced ripe tomatoes
2 cups beef broth
3 to 4 slices crustless dark bread
Salt and freshly ground pepper
Grated cheese (optional)

1. Blanch the garlic in boiling water for 30 seconds, run under cold water and drain. Peel and slice the cloves.

2. Cook the onions and peppers in the oil for 10 minutes, until wilted and golden. Add the garlic and tomatoes. Cover the pan and cook over low heat for 30 minutes. Pour in the broth and heat to the boiling point.

3. Break bread into large pieces and add to the soup. It will disintegrate and thicken the soup; adjust the amount of bread to the thickness you desire. Add more broth if necessary. Add salt and pepper to taste. Serve with grated cheese if you wish.

Yield: 3 to 4 servings.

Garlic researchers caution against assuming that their findings apply to the deodorized garlic capsules sold in health-food stores. These pills have not yet been adequately tested for their therapeutic potential, and at least some of garlic's health benefits may necessarily involve the odoriferous allicin. However, garlic that is fresh, cooked, or dried, as well as oil and water extracts, have been shown to retain potential therapeutic benefits. At the University of Minnesota, research chemists have devised a way to synthesize garlic's active ingredient—technically, allyl methyl trisulfide—the first important step in manufacturing it as a drug.

Meanwhile, for those who have only the culinary herb to rely on, two methods of countering garlic's social liabilities have been suggested. One is to chew lots of fresh parsley after eating garlic (the green herb's chlorophyll is said to act as nature's mouthwash). The other is to get everyone you know to eat garlic too. Garlicky hands, counter tops, and utensils can be cleansed with a bath of lemon juice or a generous sprinkling of salt, followed by washing with warm, soapy water.

Further Reading

Those interested in reading further about garlic might try these books:

The Book of Garlic, by Lloyd J. Harris, Panjandrum/Aris Books, Los Angeles, 1974, $8.95; paperback of folklore and recipes.

Garlic, by Sue Kreitzman, Harmony Books, New York, 1984, $5.95; paperback containing 101 recipes and some folklore and tips.

The Garlic Lovers' Cookbook, by the Gilroy Garlic Festival Association Inc., Celestial Arts, Millbrae, Calif., 1980, $6.95; paperback (Gilroy bills itself the garlic capital of the world).

Photos by Ellan Young

Syrilla Young tends the benches.

GLIE Farms . . .

A FLOURISHING HERB FARM IN THE BRONX

Kevin C. Shank

The look on their young faces was one of wide-eyed surprise and a tinge of disbelief as I held high a basket of flowering nasturtiums and said, "you can eat these flowers." The group of children, amazed but delighted, had come to visit our "farm" across the street from their nursery school in the South Bronx.

Nasturtium flowers are but one of many culinary herbs produced and marketed by GLIE Farms to New York's finest restaurants and hotels. The irony of where they are grown is just one of the surprises that awaits visitors both young and old.

Ours is an unusual block by South Bronx standards. Sure, one sees abandoned, fire-gutted tenements looking forlorn and disturbing. Yet, one also sees hope. There are three well-attended churches, a group home for runaway teens, the nursery school, and the farm with its five greenhouses, raised-bed planters and clapboard-sided "farmhouse" turned offices. It's a little-known, but amusing fact that the whole area remains zoned for farms and greenhouses.

Perhaps the farm, with its local workforce, heralds a rebirth of farming in the city. Preposterous, you may think, and so did I when we began a little over three years ago to turn a rubble-strewn, vacant lot wedged between two abandoned tenements into a principal supplier of fresh-cut culinary herbs in the city.

Getting Started

The process of creating the farm from scratch was not without difficulty. It was achieved through hard work, long hours, commitment, and financial support on the part of many people willing to take a risk on a seemingly preposterous idea. It is an idea whose time has come in the midst of alarming local unemployment and large amounts of vacant space.

GLIE Farms is named for the child care agency that owns it. Group Live-In Experience, a provider of housing and services for abandoned and runaway teens. The farm, a novel business, was started primarily as a means of providing jobs. Agriculture, the way it is practiced here, is very labor intensive. Most of the regular, full-time employees are adults from the neighborhood and the farm has provided jobs for nearly two dozen teens from GLIE since we started.

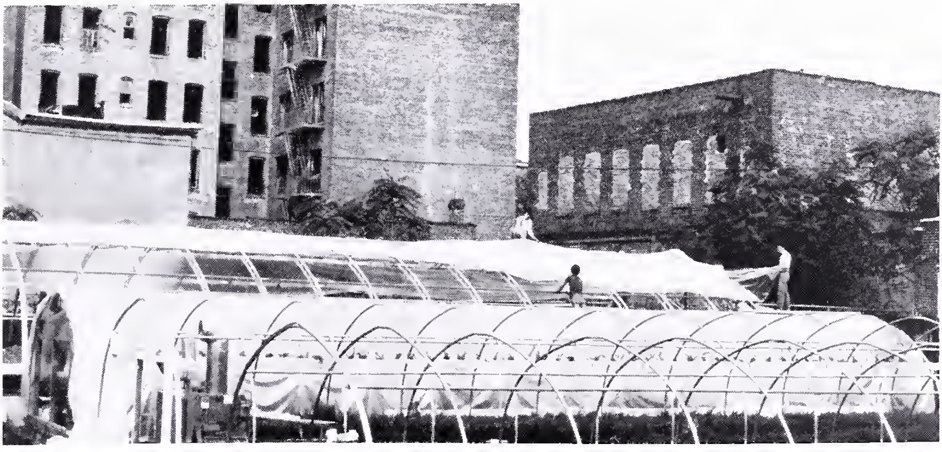
A crucial challenge, after the lot was cleared, the abandoned house renovated as offices, and one greenhouse erected, was deciding what to produce. It must, we reasoned, fill a need in the burgeoning marketplace of the city. Trial and error, as well as advice from food experts, led us to a choice selection of culinary herbs. Ranging from basil to thyme, our list of herbs would please and impress the most accomplished and demanding chefs, of whom there are many in New York.

Making Progress

Face-to-face contacts in the kitchens of the most prestigious restaurants, with a basket brimming with largely-unavailable herbs unmatched for freshness and quality, put us on the road to a thriving business. As our reputation for service (herbs are delivered daily) gained, so did the number and extent of the accounts. While it still provides a thrill, it is commonplace to be sending cut herbs as far away as Montreal, Washington, D.C., or Phoenix, or to be packing herbs destined for a dinner party for the elite and wealthy of New York.

Our productive capacity has fallen short each step of the way. To increase the number of jobs at the farm and the quantities of herbs we can produce, the Port Authority of New York and New Jersey has refinanced GLIE Farms. The refinancing is enabling us to build state-of-the-art greenhouses in Bathgate Industrial Park, south of our present site. When completed, the work force will double.

While we will miss the quaint farm at 1818 Bathgate Avenue, we won't miss the early days of no heat or running water. The new greenhouses represent a quantum leap into the future. The lessons learned will be carried forward. It is in the beginning of projects like this that the greatest perseverance is required—and faith. Faith that if a tree grows in Brooklyn, French tarragon can thrive in the South Bronx. ❦



The author (upper left) and his crew repairing a greenhouse roof.

MENDING LAWNS

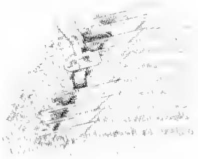
Rosalie H. Davis

Nicks and bruises on lawns planted with cool-season grasses like bluegrass, fescue, bentgrass, and rye are best mended in fall. Repairing small patches of turf is usually a simple task if the rest of the lawn grows well and gets good drainage, regular fertilizing, lime as needed, and enough light. Likewise, sparse turf under deciduous trees can sometimes be restored by merely adding lime and reseeding with a shade mixture. Reseeding isn't even necessary in many cases. The yellow medallion of grass killed because it spent a hot afternoon under a forgotten watering can will grow back. Healthy grass spreads by underground stems, and these should quickly fill in broken spots, under good conditions.

Take the time at the outset to identify the cause of problems. Make sure you know what disease and insect pests are damaging your lawn before treating it with pesticides. A soil test can be an invaluable aid; it will tell you if your soil is acid or not, and if you should lime; whether you should feed it nitrogen, potassium, phosphate, or all three.

The seed you plant should suit the needs of your lawn: a lawn that is only looked at doesn't require the same kind of strength as a football field. Study the labels on the seed boxes and bins at your garden center. Mixtures are useful because they combine the beneficial traits of different grasses.

1. There are always places in a lawn that become compacted for one reason or another. You can rent or buy enormous machines and attachments for lawnmowers that will aerate lawns, but for small sections it is just as effective to perforate the soil with a long-tined fork. (Water the day before to soften the turf.) Rake in some good loam, level, and reseed.



2. A little bit of thatch is a good thing and acts as a mulch, but a lawn more brown than green is not. A thick mat of brown, dead grass (thatch) blocks water, air, light, and fertilizer on their way to grass roots. Cutting the thatch will help speed decomposition of dead grass. With a thatching rake, use a push-me-pull-you motion to cut through the mat of dead growth.

If you turn up a lot of old thatch, rake it out of the lawn. Fertilize with a slow-release 30-10-20 (or similar formula). If the lawn has thinned out, use a starter fertilizer (6-12-4 or 18-24-6) and reseed. The seed should catch hold on the renovated and scarred surface.

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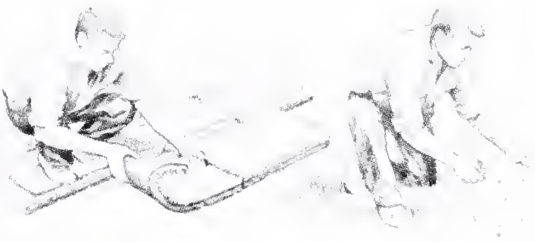


Illustrations by Elayne Sears

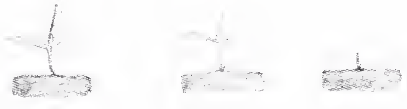
3. a) Broadcast seed over bare spots and thinning areas, crisscrossing it to assure thorough coverage. The rate of sowing depends on the kind of grass you're planting. Rake it in lightly so that the seed is thinly covered. Tamp gently with the back of a garden rake or roll the new seed bed. Mulch with a thin layer of straw or salt-marsh hay, or peg down a screen of cheesecloth. Most grasses should germinate within two weeks, depending on the temperatures of soil and air (and the quality of the seed mix).

b) The warm-season grasses of the South (like Bahia, Bermuda, Saint Augustine, and zoysia, to name several) are widely sold as sprigs or sod plugs, and over small areas these are easy enough to set out by hand. Generally, warm-season grasses are best planted in spring. Plant sprigs of grass or sod plugs much as you would any garden perennial, setting the crowns of the plants at ground level. Shallowly cover the rhizomes and roots. Space sprigs about 6 inches apart, plugs 12.

c) On slopes, sod establishes itself more quickly than seed and so diminishes erosion. Unroll the turf and stagger the courses to avoid long unbroken seams. Don't step on the turf if you can help it: if you must, put down a board or pallet to stand on. Snug the pieces of turf up against one another and tamp them gently in place. Edges should be trimmed off neatly.

4. Water seed and seedlings, sprigs and sod plugs, and newly laid turf. For seeded areas a fine spray is best until new grass can hold its own against jets from a sprinkler. All plantings should be kept well watered until thoroughly established, even when this means several waterings a day. After grass has sprouted, continue frequent waterings, for young grass seedlings are especially vulnerable to drought.

5. Grass should be 3–4 inches high and the turf knit together before the first mowing. Make sure the mower blade is clean and sharp; a gummy or dull edge can yank out new seedlings. The blade should *trim* the green leaves (note details). If you cut them *off*, you have another place to fix before long.



Before mowing A good cut Too low

Photos from color slides by George Taloumis

Platycodon (Balloon flower)

ONE MAN'S WAY TO AN EASY-CARE GARDEN

George Taloumis

There is no such thing as a garden with no maintenance. But you can have a garden of *low* maintenance.

Much has been said and written recently on easy-maintenance gardens. Instead of lawns, use ground covers. Turn barren areas into paved terraces, place mowing strips along borders, keep to the hardiest plants. Emphasize disease-resistant varieties (especially in tomatoes and crabapples), and kinds that tolerate drought. Cut down on the area gardened.

In my own large border, varying from 9 to 15 feet deep and running 60 feet along a

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Reprinted with permission from *Flower and Garden Magazine,* June/July 1984 stockade fence, I have been emphasizing low maintenance by careful selection of only hardy perennial plants, whether woody or herbaceous (die-to-the-ground) types—kinds that live on through the years.

My garden, in Peabody, Mass., is in Zone 6b (USDA Plant Hardiness Zone Map). My choices will not do for everyone, but may be a guide for many, and are based on long experience.

For the permanent year-round garden structure—the background—I use trees and shrubs that bear flowers for seasonal color. In the back are taller sorts. My favorites are the dogwoods (*Cornus florida,* the flowering dogwood; and *C. kousa,* the Korean); laburnum, lilacs, azaleas, and rhododendrons. Farther front are dwarf shrubs including evergreens to give winter color.

Among the flowers, which form the mainstay of the forepart of the border, I have settled on strictly perennial kinds that are hardy, non-spreading, and pest-free. These I use in abundance. Two of the best are *Amsonia,* a blue-flowered gem which is as tolerant as a plant can be, and the gas-plant *(Dictamnus albus).*

For early spring, few perennials surpass the gold-dust *(Aurinia saxatilis),* but a special favorite variety of it is the lemony yellow 'Citrinum'. The gray-green foliage looks good all winter, and makes a wonderful curtain growing atop a low retaining wall. In shade, a superb combination is the summer bleeding-heart *(Dicentra exima)* mixed with royal or maidenhair ferns. Or you could substitute the similar but newer bleeding-heart *D.e.* 'Luxuriant', with deeper coloring and better suited to sunny positions. Any of the hostas, also, are top choices for shade.

Plants To Avoid

Just as important in this discussion are the kinds of plants to minimize or avoid, if low maintenance is your aim.

Amsonia, or bluestar, is a blue-flowered hardy perennial that is pest-free and doesn't become a romping nuisance in the border.

FAVORITE PERENNIALS FOR LOW MAINTENANCE

(S = will grow in shade)
Phlox
Balloonflower *(Platycodon)*
Helenium
Gold-dust *(Alyssum* or *Aurinia saxatilis)*
Amsonia
Gas-plant *(Dictamnus albus)*
Summer bleeding-heart (*Dicentra eximia*) and its hybrid 'Luxuriant' (S)
Native ferns (S)
Hostas (S)
Yarrow 'Coronation Gold'
Seaside goldenrod
Hellebores (such as Christmas-rose) (S)
Peonies
Daylilies
Purple cornflower
Epimediums (S)
Liatris

TALL SHRUBS AND SMALL TREES

Flowering dogwood
Korean dogwood
Lilacs
Forsythia 'Lynnwood Gold'
Washington hawthorn
Japanese maple
Korean azalea
Rose-of-Sharon *(Hibiscus syriacus)*
Linden viburnum *(V. dilatatum)*
Wright viburnum *(V. wrightii)*
Sea buckthorn (*Hippophae rhamnoides*)
Laburnum
Silverbell *(Halesia)*
Sourwood *(Oxydendrum)*

LOW EVERGREEN SHRUBS

Wilson rhododendron
PJM rhododendron
Azaleas (hardier varieties)
Mahonia aquifolium
(Oregon grape-holly)
Leucothoe
Andorra juniper
Mountain-laurel
Pieris
Kingsville boxwood

LOW DECIDUOUS SHRUBS

(leaf-shedding)
Euonymus alatus compactus
(dwarf winged euonymus)
Slender deutzia
Potentilla
Floribunda roses
(my pet is 'Betty Prior')

First, annuals. I have cut down my uses of them because they need setting out or, if self-seeding, they need thinning and/or transplanting. They also need frequent deadheading to be presentable, and more watering than perennials.

Next, spring- and summer-flowering bulbs are avoided, as they need planting, lifting, dividing, and storing. They also leave bare spots in the garden and their ripened leaves have to be removed for a neat appearance.

I try to bypass any plants that need winter protection in my climate or are border-line hardy. In my case this means *Tritoma* (red-hot poker), lavender, *Caryopteris*, blue hydrangea, and *Vitex*. It also means hybrid tea roses, because they need winter protection.

Avoid planting any perennials that spread so fast you must always be digging out the excess. Some which for that reason are on my list of no-no's: *Physostegia* (false dragonhead), bee-balm (*Monarda*), lily-of-the-valley, hardy asters, lamb's-ears (*Stachys byzantina*), costmary and mints (unless you have them in large containers plunged in the ground for containment).

Avoid any that are downright weedy—as I regard the goutweed *(Aegopodium)*, and Chinese lanterns *(Physalis alkakengi)*.

Avoid perennials that are short lived: delphiniums, coreopsis, gaillardia, violas, gloriosa daisies. Also avoid biennial types. Some well-loved flowers come into this group, but we are talking about low maintenance.

In vines, avoid vigorous twiners that need regular hard pruning, such as wisteria and Chinese fleece vine *(Polygonum)*.

Little Weeds Mean Many Seeds

Ray R. Rothenberger

As we approach the end of the gardening season, we often ignore the small weed plants that remain. The vegetable or flower plants are large, and these last generation weeds of the summer seem of little consequence. However, hidden among the larger plants, these little weeds are able to produce abundant seeds for next year.

Good weed control in fall can greatly reduce the weed population that develops next year. Of course, seeds of some weeds will blow in with the wind and others will be brought to the surface during cultivation so we will not be totally weed free. However, yearly vigilance can ease the weed problem considerably.

Although different localities have their special pests, some of the most common weeds that are able to produce seeds from late germination are pigweed, crabgrass, goosegrass, smartweed, carpetweed, purslane, prostrate spurge, ragweed, three-seeded mercury and quickweed (*Galinsoga*).

Herbicides are relatively useless as this late weed crop develops. Desirable plants are too close to spray them. Preemergent herbicides would have been effective if applied earlier, but at this time they would have no effect on these weeds. Although herbicides may still be used, existing weeds would have to be hoed or tilled out. This late cultivation would be more effective leaving few weeds other than winter annuals or dandelions to still germinate after a late August cultivation. Gardens that are mulched will seldom have a severe problem with a late summer weed crop.

If a section of the garden is lying idle because a crop has been removed, do not allow weeds to fill it. After the crop is finished, start a green manure or winter cover crop to improve soil and prevent erosion. Ryegrass or oats can make a good cover crop if planted in late summer or fall. These grasses keep down weeds, keep the soil from eroding, and can be cut and plowed down in spring to add organic matter to the soil.

While vegetable plants such as corn, cabbage or beans are still green, but have been harvested, plow them under while plowing down weeds. Plant tissues decompose faster in the soil while still green, especially heavy stems such as corn stalks.

Even weed seeds that are not mature will decompose under the soil. Those that are mature, however, will remain in the soil if plowed under, so should be cut off and removed before they shatter from their seed heads.

While most weeds can be killed successfully by plowing under, a few are a special problem, and should be removed from the garden if at all possible. Among some of the most difficult are purslane, nutgrass and Bermuda grass.

Purslane, in addition to producing abundant seeds, will root easily from sections broken off during tilling. Bermuda grass also roots easily from sections. Nutgrass produces both seeds and nutlets which are easily spread while working the soil.

These three weeds are very difficult to eliminate once they have been spread throughout the garden. They are a good example of the saying "an ounce of prevention is worth a pound of cure." Whenever they are first seen, they should be promptly removed.

Invasive weeds, such as Bermuda grass, may have to be pulled out among other plants, but after removal, the garden should be edged with a herbicide such as glyphosate (Roundup, Kleenup) that kills the invading stolons. Purslane plants should be pulled and removed as small plants, since they begin seeding while very small. Nutgrass should also be pulled early in the season. Pulling it in summer may improve the garden's appearance, but many nutlets will remain behind to start next year's crop. ❦

Reprinted with permission from *The Gardener* (Men's Garden Clubs of America), July–August 1984.

Stachys byzantina and *Viola tricolor*

Photos from color slides by Pamela Harper

IN PRAISE OF COMMON PLANTS

Frederick McGourty

Three or four times a year I am dragged, kicking and screaming, to a cocktail party by a wife who accuses me of becoming a hermit. I am not very good at such affairs and usually retreat to study a bookcase if I think I can get away with it. No one bothers a bibliophile, especially one who

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reads books. Every so often there is no bookcase, and I have to stand by the brie talking with someone whose eye reaches beyond my shoulder as soon as I answer her question about my occupation—a horticulturist. Not surprisingly, the conversation turns to cheese, and I remark about my fondness for brie, even when it is heated and has almonds on it, which seems increasingly the case in the complicated eighties. At the last bash this brought a swift retort: "But it's *so* common. Nobody serves it at the better parties anymore. Everyone's into chevre now, with shredded macadamias on top." I almost spilled my Campari and soda.

The same sort of thing happens when I attend plant meetings these days, too. Recently one speaker complained about the glaring ubiquity of annuals; another railed against hostas as the ornamental cabbages that are taking over America. The sneers are uttered with the sort of fervor that turf specialists reserve for lawns that have dandelions in them. I happen to be fond of dandelions, and once suggested to a lawn man that the world would be a better place if we let the dandelions grow and pulled out the grass, which gets in the way of the climax lawn. What is the sin of a dandelion except commonness? It is a beautiful plant. My turf friend realized at once that he was in the presence of an unregenerate American crank.

The fact is, it's a trendy country, and gardening, like any other field, has its share of "in" plants and "out" plants. Paperbark maple, Japanese painted fern, variegated Solomon's-seal, and European wild ginger are "in" plants, of course. "Out" plants, which may have been "in" at one time, include cannas, gladiolus (except the species, which are "in"), *Catalpa, Strelitzia,* and *Kolkwitzia.* There are regional variations, especially in California. In general, the number of "out" plants is greater in the Northeast and Northwest than in other parts of the country. There are not many in the Plains states.

Occasionally a plant is "in" in one place, "out" in another. An example is crape myrtle, which is as common in the South as watermelon but undependably hardy in New York, hence valued. I know a person who grows a Japanese windmill palm *(Trachycarpus fortunei)* on an island off the Massachusetts coast. This specimen is a far cry from one grown in Ireland or Cornwall or even Norfolk, Virginia, but it is treasure in the eye of the owner-beholder. A few advanced plantsmen like *Gaura lindheimeri,* a perennial wildflower from Texas with white flowers resembling moths who have been through a hailstorm. It is not very well known among gardeners, and it is not intended to be. *Gaura* is one of those plants with quiet grace. Quiet grace, of course, is a horticultural euphemism for secondary elegance. The *Gaura* Cult has grown.

A Multinational Thistle

Along with nine or ten other people in America, I am fond of the Scotch thistle, *Onopordum acanthium,* whose prickly, silver rosettes give rise the second year to very prickly, eight-foot-tall stalks. As they reach toward the heavens these become candelabras bearing reddish-purple flowers in July, much like those of the globe artichoke. Scotch thistle isn't really Scottish at all, and it was probably an Englishman who first called it Scotch, as an epithet. It is native from Europe to central Asia but has moved around in its own exuberant way. In South America it is called the Argentine thistle, probably by the Chileans.

Stately biennials such as the Scotch thistle are not easy to use in the landscape, especially ours. My wife expressed her opinion on the subject in no uncertain terms: "You'll plant those thistles in my garden over my dead body!" Mary Ann is not one of the nine or ten Onopordophiles on this side of the Atlantic, and my efforts at plant sensitivity training have not been entirely successful.

Much of the success of a garden has to do with the proper placement of plants, and I ascertained that there was room for compromise, or at least maneuvering, since Mary Ann had specifically referred to the garden, not the property. In this give-and-take, I was given the driveway as part of the settlement, with the understanding that early each August Mary Ann's son would be allowed to chop down the Scotch thistles with an ax before the seeds ripened fully and spilled over into the next county. Steven spends most of July sharpening the ax. He is not one of the nine or ten Onopordophiles, either.

Fortunately, the large driveway of our old farm is unpaved, though the soil has been compacted by two centuries of pressure from cows, horses, stagecoaches, wagons, tractors, cars, trucks, backhoes, and overweight Labrador retrievers. The evidence is covered by an inch or two of battleship gray pebbles called traprock.

I carefully chose a planting spot away from wheels, human feet, cat runs, and potential home plates of pre-teen baseball crazies. As I believe in Scotch thistles going first class, I selected a southerly location next to our barn, between a garage door that opens to a tool storage area and another door that leads to an old stable where pots are stored. There is considerable traffic between the two. When wife, young 'uns, and our nursery staff go by, they can all admire the Scotch thistles, I thought. Well, they at least look at the thistles, though not with the kind of warmth these noble plants deserve. Each person except me looks forward to early August, and there is an irreverent celebration on the appointed day of felling.

Growing Scotch thistle in gravel is a bit of an art. The improvement of the soil, as it were, consisted of incorporating several shovelsful of peat moss, worked in by pick until the pick broke. Good sendoffs are vital, so I added some super phosphate and lime, too. Actually the sendoff was more like a takeoff, and I, for one, am pleased to report that a modest naturalizing has taken place. With biennials, one must leave a few seeds to ripen *in situ* lest the species should die out, which my wife thinks an unlikely occurrence with Scotch thistle. We also let a few first-year plants remain at the base of the clump—more than we need perhaps, but the silver rosettes are pretty and form a pleasant contrast with the gray traprock and the barn-red barn. "*Genius loci,*" I always say. "Barnyard plants," Mary Ann mutters.

Johnny-Jump-Ups

I have always had a sneaking admiration for Johnny-jump-ups, *Viola tricolor,* the European wild pansy that must have come to America in the wake of the Mayflower. Few plants have had more names over the years—some sixty alone in English, including herb trinity, three-faces-in-a-hood, love-in-idleness, cull-me-to-you and heart's-ease, a name that later rubbed off on the garden pansy, which is a nineteenth-century hybrid of *V. tricolor* and one or two other species. It is not good form to admit strong fondness for Johnny-jump-ups, but they have won more friends over the years than, say, *Acanthophyllum gypsophiloides.*

Our first gardening encounter with Johnny-jump-ups occurred some years ago when Throckmorton, a quintessentially Yankee bachelor friend, dropped by with a couple of flats that had just been given to him by an older lady for whom he occasionally gardened. There were all sorts of variations in flower color, running the gamut of purple, yellow, and white, the three tints that make up the "tricolor" in the species name. Throckmorton made a point of picking them over and reserving the most colorful for himself. In fact, we were left with the purple ones, pretty enough but not what we had anticipated.

The Johnny-jump-ups were planted in one of our perennial borders, and they flowered beautifully all through the season. I began to wonder why no one gave them prime spots in the garden. The next year the reason became abundantly clear. They had increased their space to half the border, and we realized that something had to be done. One day a visiting rock gardener who thought we should have a rock garden, too, suggested that the far end of our driveway, away from the Scotch thistles, be turned into a scree. Well, water certainly does run through, under and over the driveway in late winter, and there is no shortage of small stones.

I gathered that the conditions would not have quite met with the approval of Farrer (author of *The English Rock Garden*), so I decided upon a fantasy scree in the driveway. We sprigged in a few young plants of Johnny-jump-ups, and nature took over in its inimitable way, despite the occasional intercession of automobile wheels and snowplows. Each spring there is a veritable

Hosta in the author's garden.

cavalry unit of new seedlings, and we let them gallop to their heart's content, or ease, so to speak. They are still mostly purple, which doesn't really bother us, but when we visit the gardens of friends who have good tricolor Johnnys, Mary Ann and I take a moment to admire them, which brings an odd stare from our hosts. They would rather have us appreciate their *Acanthophyllum gypsophiloides*.

The Marigold Peace Settlement

I am in my post-marigold period of gardening, but that does not mean that I cannot stop and wink at one from time to time, particularly when no one else is around. Visitors are sometimes surprised to see them in our garden. I gently point to my wife (if she is not looking), and they understand as I hustle them off to another border. Marigolds, you see, are part of the marital compromise. One June, a day or two after returning from our honeymoon, Mary Ann asked when we were going to put in the annuals. The garden looked rather complete to me, and with a guarded tone I asked what annuals she had in mind. I hoped she was planning for next year, and for color in the vegetable garden in the meadow beyond our house, out of sight. "Love me, love my marigolds!" she exclaimed. "I want them up front, right by the door. Orange ones, yellow ones, maybe some white ones, too."

I took the offensive. "Mary Ann, this is a quiet residential area. What will the neighbors think? Besides, there may be zoning regulations. And what do you expect me to tell the president of the International Meconopsis Society when he drops by for lunch?" She replied, "Tell him David Burpee is coming for dinner." That settled it. I lost.

I may have lost the war, but I was determined to win the peace. If marigolds are to be planted, one should at least go about it properly. Concessions were exacted. In return for limiting the planting by the back door to one area and with surrounding plants of my choice, I conceded to Mary Ann's color selection, 'Sunkist' orange. In addition, several window boxes by our old well would be given

The *ménage à trois* of marigold (*Tagetes* 'Spunky'), *Molina caerulea* 'Variegata', and *Allium flavum*.

to marigolds, but they had to be small, yellow, single-flowered French types such as 'Dainty Marietta', or signet types, which for marigolds are refined, especially when mixed with dusty-millers and *Nierembergia.* We agreed someday to try the low-growing foliage marigold called Irish-lace, *Tagetes filifolia,* which late in the season bears tiny whitish flowers that cannot be seen from a speeding car. Essentially, it is a marigold for people who don't like marigolds. You don't see it around much, but it is available.

But what we are really talking about is orange. It is a difficult color to get around, particularly 'Sunkist' orange. Actually, there are not many plants that have it: some cultivars of *Kniphofia,* zinnias, and calendulas; also California poppies (*Eschscholzia* sp.) and butterfly weed (*Asclepias tuberosa*), which is not the hard electric shade because the flowers are small. I thought of the times I had seen these plants displayed well in gardens, and it was usually with yellow flowers or golden-foliaged plants.

Just around this time a nurseryman friend who was trying to interest us in ornamental grasses gave us a mature plant of variegated moor grass, *Molinia caerulea* 'Variegata', which has leaves striped green and pale yellow. It makes a tidy clump about two feet tall when the airy flowers appear in late summer. What we did not know then was that *Molinia* is one of the most beautiful of all perennial grasses and looks well even in early winter when the leaves become light buff. Our friend suggested that we plant the *Molinia* near the door so we would be aware of its presence in winter.

The moor grass has served as the catalyst for a grouping of low-growing 'Sunkist' orange marigolds we planted in front of and alongside it. Also, it cools while they enhance, and the combination works. For a complement, some ornamental onions with gray leaves and soft yellow flowers, *Allium flavum,* were planted nearby. Their flowers open in a fascinating manner near, but not at the top of, the scape, from a long beak that encloses them. They bloom for a number of weeks in midsummer. This is one of the prettiest alliums, and it almost takes the minds of curmudgeons off marigolds.

Ever-So-Sweet Alyssum

There are few banal plants, just banal sites or banal combinations. One annual that I have never found banal in any way or location is a low-growing plant from the Mediterranean world that most gardeners take for granted—sweet alyssum, *Lobularia maritima.* There is no need to describe it here except to say that there are purple- and rosy-pink-flowered variants of the usual white-flowered mat, 'Carpet of Snow'. As an edging plant, the last has bound down many a border that otherwise would have been strident red or yellow clouds floating in space.

I like sweet alyssum best, however, as individual specimens planted among low-growing foliage plants of patrician but slightly obese form, such as *Bergenia* or the first-year rosettes of the wonderfully felty silver sage, *Salvia argentea.* One pleasant use of 'Royal Carpet' sweet alyssum, which has purple flowers with a bit of white, is to intersperse it among plants of this superb sage, where the alyssum provides textural change but color compatability. The two, in turn, are guarded as a distinct garden scenario by a background of lavender-blue *Stokesia,* in turn overseen by purple coneflower, *Echinacea purpurea.* The flanks are safe from invasion if there are some grays, pinks and whites defending them. There is no shortage of choices. These are cool, lingering scenes for the beach days of summer.

Sweet alyssum differs from most annuals because it is frost tolerant, and even in our wretched New England climate there may be some flowers as late as November. It also self-sows, and each year there is usually a new batch of seedlings near where plants were the year before. I simply spend a few minutes each spring rearranging them and discarding the excess.

One of the loveliest uses of sweet alyssum is simple abandonment. A few years ago a landscape designer friend took me on a tour of gardens in Beverly Hills. We stopped at a posh hotel where there were fine, rather elaborate designs with many plants I knew only from straitjacket culture in greenhouses. I don't relate to such plants very well but was aware that praise, or at least gentle comment, was expected.

Then, off to one side appeared a brick terrace covered with low white mounds. Sometime before, the area between the bricks had been given to sweet alyssum instead of the customary mother-of-thyme, and it had filled the openings beautifully and lavishly. My friend was disappointed that my attention was focused on such common plants, so I made a point of speaking favorably about some lantanas nearby, which made matters worse. But then, even the cracks of Los Angeles sidewalks are fascinating to northeasterners whose plants of red valerian (*Centranthus ruber*) or Mexican fleabane (*Erigeron karvinskianus*) have faded away. One man's garden flower is another man's weed.

An Old Soldier Among Hostas

Much has been written lately concerning new hostas, often with condescension toward older sorts. Reading the future requires more tea leaves than reading the past, but some of the novelties that have foliage of real distinction—among them 'Francee' (with silver variegated leaves), 'Gold Standard' (chartreuse with green edge) and 'Krossa Regal' (with gray foliage and five- or six-foot-tall scapes)—will likely be valued for years. A host of others, fairly good soldiers though they may be, are apt to fade away. The word "new" has special appeal for gardeners, and in horticultural parlance it is considered synonymous with "better," much to the satisfaction of everyone but a few mossbacks, curmudgeons, and blockers of general progress.

I suspect that a few of the older hostas will survive the onslaught. One that I see everywhere these days, from plantings of other times, is *Hosta lancifolia*, which makes a serviceable edging or ground cover, although the glossy green leaves are small for the genus. It is still one of the best hostas for flowers, which are rich lavender and borne in the latter part of summer after most other hostas have ceased blooming. *Hosta lancifolia* is almost indestructible, a trait not always appreciated by nurserymen. Like marigolds, it has suffered a lot from banal uses. However, as a ground cover under the common, almost overpowering peegee hydrangea, *H. paniculata* 'Grandiflora', whose white snowballs of flowers appear at the same time this hosta is in bloom, the effect is very pleasing.

I also like to have a group planting of *Hosta lancifolia* in a shaded spot near several clumps of *Astilbe taquetii* 'Superba', which grows three to four feet tall and has steeple-shaped clusters of flowers the color of black raspberry ice cream. Their bloom periods overlap, as does that of *A.* 'William Buchanan', a lovely, shiny, cut-leaved plant that has eight-inch-tall clusters of white flowers. This is one of the most vigorous of the really dwarf astilbes and is itself a candidate for ground cover in a small area.

I have made a fair number of divisions of *Hosta lancifolia* over the years for our own garden as well as for the nursery. Toward the end of one spring afternoon several years ago, my fingers were almost numb from breaking up large clumps of this hosta, and the barn floor was littered with its fresh young leaves. The telephone rang. It was Mary Ann, delayed in a neighboring town and asking me to get dinner started. She said that some spinach was in the refrigerator.

It was a cold day, and I needed little prodding to enter the kitchen. Meal preparation went well once my thumbs had thawed, but we were short on spinach. Not long before, a gardening acquaintance versed in ways Japanese had casually mentioned to me that hostas were used occasionally in the Orient for cooking. Inspired, I dashed to the barn, picked up the afternoon's leavings, and returned to the kitchen. After washing the foliage carefully and removing the pithy midrib, I mixed the hosta leaves with the spinach.

Cooking was brief, and I was busy chopping the greens as Mary Ann came into the driveway. Dinner was on the table in a flash. I surreptitiously watched her as she ate the concoction, because she is usually able to detect anything out of the ordinary, down to the tiniest anchovy I might add to spaghetti sauce. The "spinach" passed muster, or at least went without comment, and I eventually took a few bites, too. Hosta greens probably don't have much of a future in the American kitchen, but they're nice to know about if you run short on spinach or have too many lancifolias in the garden. . . . ❦

GARDEN EDGINGS

Margaret Hensel

Lines are forever being drawn in a garden: beelines between house and garage; great, sweeping curves between shrub borders, lawns, and flower beds; and divisions between formal and informal plantings. These garden edgings—as revealing as the lines in a person's face—tell us as much about a gardener's character and style of gardening as do the plants he or she chooses.

For some gardeners, the line between a stone path and a woodland hillside of ferns and wild plants is a place of gentle coexistence, where plants and grasses self-seed, and leaves are left where they fall. For others, an edging is a hard line, both in style and approach; brick or metal strips sunk into the ground become vigilant defenders against encroaching weeds.

Varieties of Edgings

Regardless of a gardener's stylistic idiosyncrasies, however, the selection of edging material will influence the mood and character of garden areas. A corrugated metal strip sunk into the ground or an assiduously weeded strip of bare ground or gravel is, undeniably, a utilitarian barrier against weeds. But a mass of billowing *Alchemilla vulgaris* between herbaceous border and stone path can give a garden a sense of stylistic unity, and, once established, can be so dense that it is practically impervious to weeds. In one country-style garden, alchemilla drifts onto the path and flowers concurrently with the border's bearded iris as if it were part of the border. On the path's other side, clumps of alchemilla not only fill what might have been an awkward gap between stone wall and walk, but also provide a strong sense of symmetry.

On the other hand, a kitchen garden can be designed for the eye as well as the palate. One such garden I know is laid out with parterres of silver-foliaged *Salvia officinalis,* which is juxtaposed with the blue-green foliage of cabbages and broccoli. Squares of feathery carrot foliage are outlined by double lines of the dusty-green, crinkled leaves of kale. The brick or stone paths are edged with various culinary thymes; thus, the edgings become a harmonious blend of utility and aesthetics.

In another example of garden edgings, the lines between garden and natural surroundings are finely and beautifully drawn. There, in the shade of a New England hillside, native *Trillium grandiflorum* and *Tiarella cordifolia* are major plantings in several beds, and also used as edgings. In this case, the forms and growth of these plants influence the shape of the paths.

In this same garden, *Asarum europaeum* and *T. grandiflorum* edge stone steps. While this species of *Asarum* is not native to New England, its glossy leaves make an elegant edging in combination with *T. grandiflorum;* the duo is in total keeping with the woodland character of the garden. Although *A. europaeum* is appropriate in a woodland setting, it is so versatile that it is equally effective in formal settings. Planted as an edging along brick-edged perennial borders, this plant is quietly magnificent in the company of *Iris sibirica* and *Viola cornuta.*

Using New England Stones

A strong sense of stylistic unity is created in another New England garden by using the same type of stones in walls, paths and edgings. Here, the lower annual beds are outlined with irregularly shaped stones set on end, while the upper shrub and herbaceous borders are edged with straighter, more continuous lines of the same stone.

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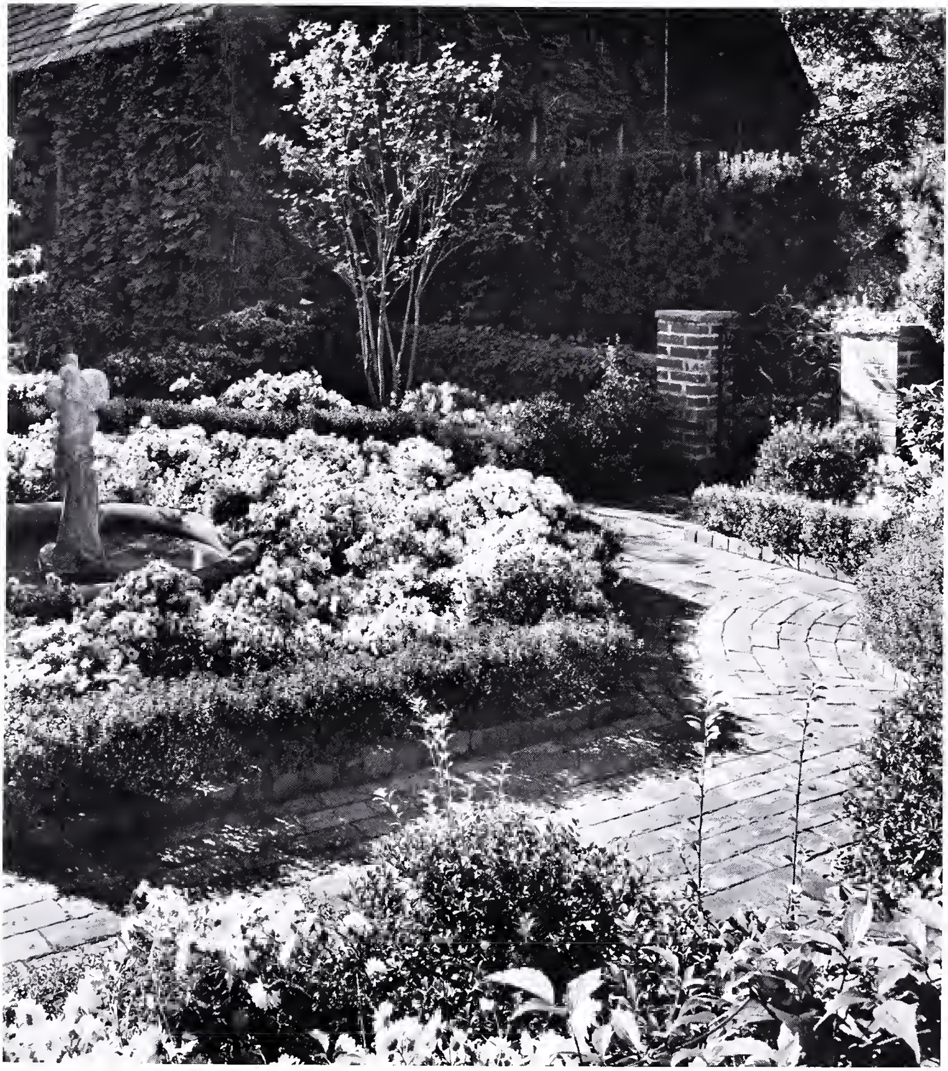
The result is a successful division between two distinctly different borders. The roughly shaped stone edgings of the lower border are a dramatic break from the smoothness of the lawn. At the same time, the stone continues the line created by the lowest step while lifting the eye up to the upper border. At the edge of the upper border, the continuous line of stone is a simple repetition of the wall below and the higher stone wall behind.

These lines of stone fend off encroaching grass and prevent plants from spreading and flopping onto paths. Of equal importance, however, is the visual unity the stones give this garden. What might have been a confusion of levels and directions looks, with skillful manipulation, like a natural outgrowth of the surrounding woods and hillsides. ❦



Gottscho-Schleisner

Curves in brickwork are softer to the eye, yet make a clear boundary to keep plants contained. The low hedge reinforces the design.

THE RETURN OF THE WILDFLOWERS

Paul F. Frese

Many homeowners, along with garden clubs and administrators of public spaces, are currently taking a strong interest in wildflowers for bloom along roadsides and in lawn-meadows around homes and other buildings.

The way it is told, seeding such stands is easy, and once established, the flowers largely take care of themselves, eliminating much mowing and maintenance cost.

While most of this is true, there are reservations—for we are dealing here with seed mixtures comprised of a great number of different plants including both garden flowers and native kinds.

Recently I looked into a few such projects to find out what it takes to be successful in naturalizing wildflowers from seeds. You will find seed mixtures widely advertised and available. Different mixtures are offered for different areas of the country, or diverse conditions such as dry or wet, cold or hot. Some contain both annual flowers, for first-year show, and perennials, for permanent effect. To get them started requires just as much attention to details as is needed to make a flower border.

All the wildflower project managers I contacted agreed that it is hopeless to scatter seed over grass or weedy places, or rough land, with the expectation of getting the flowers to thrive. Seed must be sown on bare soil, prepared as you would for a flower garden. An exception might be rocky places, where the seed would be covered with peat or a similar mulching material.

As a test, a 40-foot-square piece of open land in our condominium village was chosen as a site for a wildflower meadow. Only rough grasses and a sprinkling of native flowers grew there. The place had been customarily mowed once a year.

Following instructions from the supplier of seeds, the land was first thoroughly rototilled. Rough stubble was raked off to make a smooth bed. A standard wildflower mixture was sown by hand, mulched with salt hay (recommended, where available, because it does not contain seeds); and with a garden hose the area was kept watered during dry spells because moisture is essential during the germination period.

Results—a bumper crop of ragweed and almost no flowers.

Apparently, ragweed seeds had lain dormant in the soil depths since the ground had been graded 13 years before. Tilling brought them to the surface. An experience similar to this was reported by the American Horticultural Society when attempting to make a wildflower meadow at River Farm in Virginia. Their surprise crop was pokeweed.

Heading Off Weeds

So, how can the weed problem be eliminated?

One way is to blanket the prepared seed bed with black plastic for two months or more prior to planting. It should remain long enough to force weed seeds to germinate and be smothered in the hot darkness. Anthony and Rene Donaldson reported using this method in establishing a prairie-type planting around their Illinois home, in *Garden* magazine, May-June 1981 (published by the New York Botanical Garden, Bronx, N.Y.). That article contains detailed procedures and the kinds of plants they used.

If a lawn area is being converted, tilling

Reprinted with permission from *Flower and Garden Magazine*, April/May 1984

Photo from color slide by Paul Frese

The first summer after planting a typical wildflower mix. Corn poppy, scarlet flax, calendula, batchelor's button, baby's breath, sheep fescue, and evening primrose provided a handsome display. The second year the only survivor was the evening primrose.

of the turf to make a seed bed is not recommended. Instead, the sod should be stripped off. In small plots you can do this with a spade. On larger areas you may choose to rent a power sod cutter, or hire a landscape company to come and strip off the sod for you.

Another method of weed control is based on waiting until midsummer to prepare the seed bed. When it is ready, begin watering it, and keep on watering periodically to bring up weed seedlings. As weeds appear, spray them with contact systemic herbicide Roundup, diluted in water according to label directions. Wet the weeds with it. More than one application may be necessary to kill all growth. Then sow the wildflower seeds in autumn shortly before freezing weather. Roundup is a standard weedkiller used by nurserymen to kill weeds around nursery stock. It is easy to keep off desirable plants, but destroys all green vegetation that it falls on. The wildflowers should come up the following spring without the usual flush of weeds.

Where you wish to plant wildflower seeds in spring, spray Roundup on weeds in the area up to a week before seeding. Regardless of when you plant seeds, some weeds will come up and must be hand pulled. It is important to learn how to distinguish seedling weeds from flowers.

In preparing the seed bed, loosen soil to as deep as six inches, adding peat or other humus if soil is excessively sandy or clayey. Fertilizer is rarely needed, as feeding favors weed growth more than it does the flowers.

Sow seed mixes as directed, usually

about four ounces to 1,000 square feet, or four to six pounds per acre. Seeding rates are furnished by the firm packaging the seeds and vary widely, depending on the kinds of plants represented. Nurse grasses are often included in a mixture, particularly in a blend for seeding on slopes to prevent erosion. Red fescue or sheep's fescue are popular for this at the rate of one-half pound per 1,000 square feet. Competitive grasses such as annual ryegrass should never be used.

Seeding may be done by hand or with a mechanical seeder. An easy method is to mix seeds into a bucket of sand, and scatter the mixture. The sand helps you see where seeding has been done, and also helps gauge the proper rate. Rake the area lightly afterward.

Subsequent watering is critical, especially for spring sowings. Water the wildflower plot as frequently as you would a spring planting of lawn grass.

Opinion is divided as to which is better, spring planting or fall. If weeds were no factor, the quickest results would assuredly come from spring planting, particularly if the mix contains annual types.

Germination habits of some perennial wildflowers are not fully understood. It is known that some need stratification (a period of moist cold) to break dormancy. In those cases, there is advantage in sowing in fall. An example on this point would be butterfly weed, *Asclepias tuberosa,* which has been demonstrated to benefit from stratification in moist sand at 35 to 40°F for six weeks prior to sowing in a starting medium under lights, kept at 75°. Even then, germination takes several weeks. The refrigeration period is timed so as to have strong plants ready to set out in the garden by spring.

Types of Mixes

Many seed houses and specialty firms now offer wildflower seed mixtures designed for naturalized plantings. They use the term "wildflower" loosely, as most mixes contain garden-type annual flowers such as scarlet flax and baby's-breath, to provide immediate color, along with native perennials that cannot bloom until the second year or thereafter.

Firms supplying the most complete mixes formulate them for different geographic regions. For each, the mainstays are perennials native to the region. A mix may contain as many as twenty different annuals, biennials and perennials to provide a long period of bloom. Some firms list kinds separately, enabling you to select those best suited to your locality or interests.

A typical mix for the Northeast might include New England aster, yarrow, black-eyed Susan, ox-eye daisy, cornflower, catchfly (*Silene*), corn poppy, chicory, purple coneflowers and evening primrose (*Oenothera*). Some of these will flower in a few weeks following spring sowing; perennials in the mix will not bloom until the second year.

Even though most seedsmen store seeds under ideal conditions, the percent of germination of seeds may vary, depending largely on the kind of seeds. Some may be as low as 60 percent. This of course affects the stand of flowers and makes some disappointingly sparse.

Helpful information on how to germinate wildflower seeds is to be found in a 330-page book titled "Directory to Resources on Wildflower Propagation" prepared by Missouri Botanical Garden under sponsorship of the National Council of State Garden Clubs, Inc. The contents are divided for six geographic regions of this country. For each region are tables listing plants by families, with data on life cycles, propagation methods, seed treatment, soil moisture requirements, flowering times and heights. Following these are lists of further published reading matter, researchers, and plant sources for the region. Copies of this excellent book can be had for $3 ppd. from National Council of State Garden Clubs, Inc., 4401 Magnolia Ave., St. Louis, Mo. 63110.

Reports are varied as to performance of commercial wildflower seed mixes. One instance in New York produced a lovely hillside of color from annuals the first year, but only perennial evening primroses the second year. Another planting in a corporate park in Connecticut was so colorful the first year that signs saying "do not pick the flowers" had to be posted. The second year, there was little bloom, suggesting that in both cases conditions were such that the annuals did not self sow.

Wildflower Programs

Interest in highway beautification with wildflowers has been heightened by the recent founding in Texas of a National Wildflower Research Center. In 1982 Mrs. Lyndon (Lady Bird) Johnson deeded a 60-acre tract of land and gave an initial $125,000 to launch a research program. The Center's objective is to be a clearinghouse for research and information on wildflower culture and conservation. Its basic premise is that by substituting naturalized wildflowers for grass along highways, mowing costs can be reduced. In an address to the Garden Club of America, Mrs. Johnson reported that a pilot planting of 638 acres near Dallas had resulted in a reduction of over $30,000 in mowing costs. For more information on this project, write: National Wildflower Research Center, 2600 F. M. 973 North, Austin, TX 78725.

Texas is famous for the bluebonnets (lupine species) that color its roadsides in spring. The state began fifty years ago to preserve bluebonnets, and continues today with closely calculated mowing programs set up to delay mowing until after seed has ripened.

Another giant boost to the wildflower preservation movement is Operation Wildflower sponsored by the National Council of State Garden Clubs. Its objective is to promote beautification of roadsides or other areas throughout the country, and build public understanding and appreciation of native grasses and flowers.

Under this program, a cooperative roadside wildflower planting effort is established with federal and state highway agencies, defining procedures for establishing plantings, and maintaining them.

Naturalizing wildflowers along highways calls for cooperative administration. First, most highway departments ask garden clubs or other groups to donate seeds or other materials to be used in their plantings. To avoid unseasonal mowing, highways must be charted and mowing crews supervised. It is necessary to mow all plantings annually by the end of the season, with the cutter bars set high. This is to control encroaching woody plants without disturbing the perennial flowers.

Operation Wildflower conducts educational workshops across the country for highway personnel, professional landscapers, garden club members and other interested persons.

If you have purchased the flowery "Nature's Gardens" linens from J. C. Penney Co., you have been helping this effort. Through the cooperation of Spring Mills, this series was designed exclusively for sale by Penney stores, with royalties to go to the National Council's wildflower program. The Council provides cash awards annually for outstanding wildflower plantings on roadsides and public areas.

Further reading on growing wildflowers:

The New Wildflowers and How To Grow Them, by Edwin F. Steffek. Timber Press, Portland, OR (1983).

Native Trees, Shrubs, Wildflowers—Landscaping with Native Plants, by Cordelia Penn. John F. Blair, Publishers, Winston-Salem, N.C.

Gardening with Wild Flowers, Handbook #38, Brooklyn Botanic Garden, Brooklyn, N.Y.

Growing Wildflowers—A Gardener's Guide, by Marie Sperka. Harper & Row, New York, N.Y. (1973).

Wildflower Perennials for Your Garden, by Bebe Miles. Hawthorn Books, New York, N.Y. (1976).

The Prairie Garden, by J. R. and B. S. Smith, U. of Wisconsin Press, Madison, Wis. (1980).

Growing California Native Plants, by Majorie Schmidt. U. of California Press, Berkeley, CA (1980).

[Note from *Flower and Garden* Magazine] *To help those interested in wildflower plantings like those described, we have prepared a list of sources of wildflower seeds. It is free on request. Merely enclose self-addressed stamped envelope. Address: BR-248,* Flower and Garden Magazine, *4251 Pennsylvania Ave., Kansas City, Mo. 64111.* ❦

Wild Berries May Hold Hidden Danger

Ray R. Rothenberger

Plant poisonings most often occur in late summer and early fall. They happen most often to small children who because of their small size and a tendency to put berries into their mouths may receive toxic doses. In the late summer it is important to remind children not to pick and eat berries of plants they do not know. Children too small to understand should be kept away from any plant that might present a potential danger.

Most plants grown around the home present little danger of berry poisoning. However, there are a number of wild plants that should be avoided. Even though some berries are not highly poisonous, children may become ill and the degree of danger may vary with berry maturity. Even among people with a good knowledge of wild plants, incorrect identification is always a possibility.

Moonseed (*Menispermum canadense*) is a berry-producing poisonous plant often incorrectly identified. The leaves are somewhat like those of a wild grape in shape, and it produces a small bunch of bluish-black berries in a small grapelike cluster. Moonseed berries do not taste like wild grapes, but might be harvested along with them. Each moonseed berry contains a relatively large crescent-shaped seed, while grapes contain several small ovoid seeds.

One of the best known of the poisonous plants is common black nightshade (*Solanum nigrum*). A close relative, but much less common, is the climbing or woody nightshade (*S. dulcamara*). Black nightshade is an annual plant, coming up from seeds each year. It may be found in many locations where there is not too much competition from other plants and light is good. The small flowers are white with a shape similar to flowers of a tomato. Its leaves are slightly triangular with coarsely toothed and wavy margins. Some leaves may be lobed near the base. In late summer and fall plants produce small clusters of dark purple berries from leaf axils.

The climbing nightshade has similar leaves, but flowers are violet, and berries become ruby red when ripe. Foliage of these plants is poisonous, and the green berries are highly poisonous, although, as the berries ripen, toxicity decreases.

Another plant that is a source of purple berries in fall is pokeweed (*Phytolacca americana*). Although this plant is used in early spring when young, tender shoots are cooked for greens, mature leaves and stems are poisonous. Berries have been used as a dye and in themselves are said not to be poisonous, but the seeds in them contain the poisonous property and, therefore, berries should not be eaten.

Although it produces large seeds rather than berries, another plant of woods and landscapes to avoid is the buckeye (*Aesculus glabra, A. octandra*). The seeds are large, shiny and dark brown. When eaten raw by children or domestic animals, they can be poisonous.

In home landscapes, castor-beans (*Ricinus communis*) produce pretty, but poisonous, seeds which should be kept away from children. Where castor beans are used for screens or shade, the flowers should be cut off as soon as clusters form to prevent seed formation.

Positive identification of wild plants is always important before any seeds, berries or fruits are used in the home. If in doubt, throw it out. Civilizations have spent thousands of years selecting and improving fruits and berries from plants that through trial and error were found safe. We do not have to risk our own lives or health to find out.

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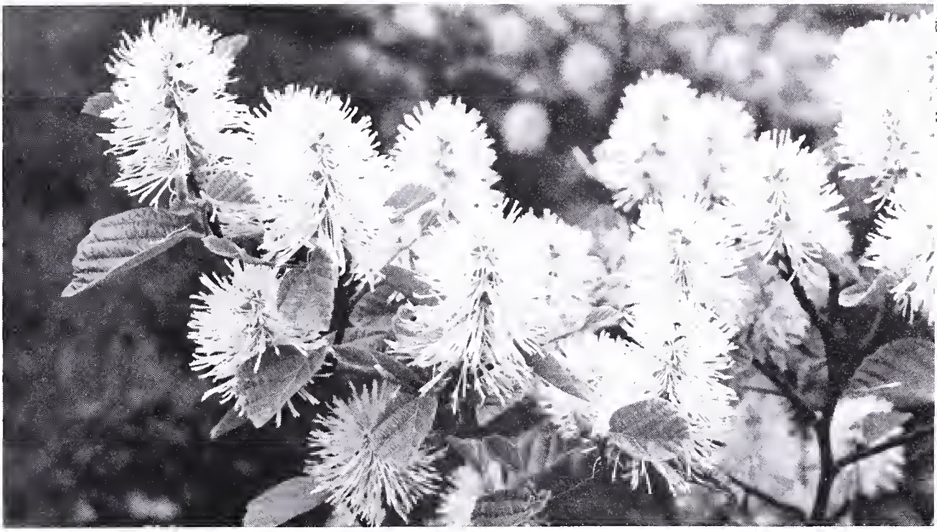
Harrison L. Flint

Fothergilla gardenii

FOTHERGILLA

Harrison L. Flint

Scratch a member of the Witch-hazel Family and you will usually find a useful landscape plant. Some of the best, yet most overlooked, members of this family, the Hamamelidaceae, are fothergillas. Also called witch-alders, these trouble-free deciduous shrubs are interesting in spring, summer, and fall.

Fothergilla begins blooming in mid-spring, near the time its leaves start to unfold. (In many areas this is also the time that eastern redbud, *Cercis canadensis*, blooms; the two make a delightful combination.) The flowers of fothergilla, borne on terminal spikes that look like bottle-brushes with numerous stamens as bristles, color the whole plant a cream or pale yellow. Since they have no petals, the showy parts of the blossoms are the stamens, each with white filaments up to an inch long, terminated by inconspicuous yellow anthers. The overall effect, even without petals, is elegant and enhanced by a light, spicy fragrance.

By the time the flowers of the fothergilla wither and fall, its leaves may be almost fully unfolded, but since they unfold below the flower clusters they do not obscure the blooms, which remain for as long as three weeks. The leaves look like those of witch-hazel, only smaller. They are pale gray-green as they unfold in spring, turning medium green in summer, and make a dense, neat mass. In autumn, they color reliably in most sites, turning golden yellow or yellow-orange, often overlaid with bright scarlet when grown in direct sun.

Native and Useful Ranges

The genus *Fothergilla*, native to the southeastern United States, includes only two species. Creeping, or dwarf, fothergilla (*F. gardenii*) grows wild at the edges of swamps on the Atlantic coastal plain from North Carolina to southern Alabama and the Florida panhandle. (*Fothergilla parvifolia* is now included in *F. gardenii;* it used

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to be treated as a different species on the basis of minor leaf differences.) Large, or mountain, fothergilla, *F. major*, is native to the southern Appalachians and the nearby Piedmont plateau, from northern North Carolina and Tennessee to northern Alabama. (*Fothergilla monticola*, once separated from this species by questionable differences in foliage and growth habit, is now included in *F. major*.)

Even though the natural ranges of the fothergillas are restricted to the southeastern U.S., both species can be cultivated as far north as the warmer half of Zone 5, where average annual minimum temperatures run as low as −15°F and all-time record lows reach −25 to −30°. This places their northern limits in eastern North America from coastal Nova Scotia and New England to central New York, and through southern Ontario to southern Michigan, Illinois, and Missouri.

Culture

Fothergillas perform well in full or half sun. If you have a choice, plant them to receive at least morning sun. Light shade later in the day may improve their performance in the hot summers of the South and Midwest. There is some confusion about fothergilla's tolerance of poorly drained soil, probably because in the wild it grows in a variety of sites, from well-drained uplands to near-swamps. (If it were possible to determine the origins of specific plants offered for sale, gardeners would know better where to use them.) Fothergilla generally will tolerate less than perfect drainage if other conditions are right, but well-drained sites are preferable, especially for the large *Fothergilla major*. They are not good plants for really dry soils or for sites exposed to strong drying winds.

Moderately acidic soil is best for fothergillas. They tend to yellow and grow poorly in neutral or alkaline soil. Even though they are not as demanding of acidity as rhododendrons and azaleas, they thrive in soil with a pH of 6.0 or lower. Soils with a higher pH, but not calcareous (containing free limestone), can be acidified with sulfur or aluminum sulfate in the same way as soil for rhododendrons and other ericaceous plants. Calcareous soil presents a special problem, as free limestone neutralizes the acidifying effect of added sulfur, sometimes rather quickly. It may be necessary to replace calcareous soil with acidic soil in order to grow fothergilla, or to build raised planting beds containing sand or acidic soil amended heavily with peat moss, wood chips, and other organic materials. Such mixtures can be spread over existing soil and contained, if necessary, by treated timbers, rocks, or masonry. Planting beds raised above the old soil level should be at least one foot deep to promote drainage and allow for settling.

Uses of Dwarf Fothergilla

Dwarf fothergilla forms thickets in its native habitat, but in cultivation it is more often seen as a small, rounded to moundlike shrub. In full sun it usually grows no taller than two or three feet, but in partly shaded sites with good soil it may reach four feet in height and six feet in width. It can be kept below eye-level by careful pruning.

Because of its size, dwarf fothergilla can be planted in the dooryard, to accent and add seasonal interest. It is especially useful in combination with evergreen ground covers such as bearberry (*Arctostaphylos uva-ursi*), Japanese ardisia (*Ardisia japonica*), English ivy (*Hedera helix*), dwarf sweetbox (*Sarcococca hookerana* var. *humilis*), dwarf skimmias (*Skimmia japonica*), dwarf cultivars of *Skimmia reevesiana*, Japanese spurge (*Pachysandra terminalis*), Canby paxistima (*Paxistima canbyi*, sometimes called cliff-green or mountain lover), or periwinkle (*Vinca minor*). Dwarf fothergilla can be used to edge a patio, at the front of a border or screen of mixed shrubs, or wherever a low shrub is needed. When planting it, always consider the seasonal color provided by fothergilla.

Uses of Large Fothergilla

Large fothergilla is variable in height and growth habit, both in the wild and in cultivation. In good soil and sites, it can range from 5 feet to more than 10 feet tall. This makes it difficult to predict whether it will serve as a visual screen or remain low enough to preserve a desirable view. To

Fothergilla's Future

If fothergillas are such superb landscape plants, why aren't they more widely used? One reason is the apparent reluctance of many gardeners to choose native trees and shrubs for landscaping. Another is that fothergillas and related witch-hazels have been considered difficult to propagate vegetatively. Thanks in part to the research of Alfred J. Fordham at the Arnold Arboretum in Boston during the 1960s, commercial nurserymen are now able to propagate both fothergillas and witch-hazels routinely by cuttings.

Briefly, the method consists of rooting leafy cuttings in flats in early to midsummer, just as the new growth is getting firm. When well rooted, the cuttings are given a very dilute solution of complete liquid fertilizer to keep them in good condition during the rest of the summer. After overwintering in a greenhouse, cold frame, or cold storage (kept just above freezing), they begin their spring growth. The key to survival of rooted cuttings seems to be to wait until new leaf growth begins before transplanting the cuttings the first time.

This technique is now routine at several nurseries, and someday fothergillas may be propagated by tissue culture as well. Given such prospects, fothergilla seems sure to become more available to landscape architects and home gardeners.—H.F.

ensure that a fothergilla will never obstruct a view, it is probably better to plant dwarf fothergilla than risk the unpredictable vigor of the larger species.

Selecting plants of *F. major* that are dependably tall for effective screening is not easy either. Select vigorous, upright-growing plants at a nursery. Even this method can mislead a gardener, however, as a plant's ultimate size cannot always be predicted from its behavior when young. The best way to select for predictable habit and rate of growth is to obtain plants that have been propagated vegetatively from mature plants of desirable form and stature. Presently, few nurserymen offer such plants, but more may in the future (see box).

On the average, large fothergilla flowers at about the same time as the dwarf type, although since the former's leaves unfold more rapidly they enhance the shrub's appearance for a greater part of the blooming period. The color of the autumn foliage is even more dependable than that of dwarf fothergilla in many locations—as spectacular a gold-scarlet combination as can be found in any shrub.

Use *F. major* in any situation where a large shrub is needed and where its spring and autumn colors are compatible with other plants and the purpose of the planting. Like dwarf fothergilla, its flowers and autumn foliage are complemented by a dark green background, such as taller evergreens provide. Suitable conifers include most true firs (*Abies* spp.), the elegant oriental spruce (*Picea orientalis*), yews (*Taxus* spp. and cultivars), and hemlocks (*Tsuga* spp.). Tall-growing hollies, rhododendrons, and many other broad-leaved evergreens are also good companions for fothergilla.

Fothergilla major also combines well with eastern redbud (*Cercis canadensis*), flowering dogwood (*Cornus florida*), and sassafras (*Sassafras albidum*); and with trees or shrubs that have complementary autumn foliage colors: the clear yellows of birch (*Betula* spp.), green ash (*Fraxinus pennsylvanica*), or spicebush (*Lindera benzoin*). Another approach is to select companions that are colorful when fothergilla is least interesting: winterberry holly (*Ilex verticillata*), with its spectacular show of fruit in early winter, and red-twig dogwoods (*Cornus sericea* and *Cornus alba*) are both colorful throughout the winter.

SHOWY DIVERSIONS FOR RHODODENDRONS

David G. Leach

Rhododendron gardens that are beautiful and beckoning the year around are produced because their creators are mindful of their deficiencies. Out of bloom, rhododendrons have all of the vivacity of a sleeping sloth.

They are not airy, nor light, nor feathery. The somber color of the dense foliage gives them the appearance of stolid burghers with feet firmly implanted beneath a solid bulk of solemn green vesture.

[Whether your rhododendron garden is established or still on the drawing board,] it makes good sense to consider companion plants for rhododendrons. The companions should provide contrasting diversion from the portly gravity of the star performers in their off season.

Gardeners often plan a new planting or the remodeling of an old one while viewing the site when the weather is pleasant. This means that virtually all shrubs and trees are in leaf at the time.

Although it seems elementary, the most common oversight in planning a rhododendron garden is anticipating the winter effect when deciduous shrubs virtually disappear after their leaves drop.

Winter Considerations

Borders suddenly have voids. Paths develop unlikely gaps in the plantings that define them. Land groups lose their coherence. Only hollies, mountain laurel, conifers and other evergreens should be used as companions in the essential design of a garden featuring rhododendrons.

In conifers, the rich, deep green pines and firs reinforce the sober tonality. It is much better to enliven the garden with lighter, brighter green-needled trees which the nurseryman is likely to have hidden in the back of his sales lot.

The red pine (*Pinus resinosa*) is usually a buoyant green. There is a form of white pine (*P. strobus*) called "Hillside Winter Gold" that is a meld of amber and pale green. It contrasts beautifully with rhododendrons and lends a spirited accent to them. The blue-green Korean pine (*P. koraiensis*) is a pleasant partner, reminiscent of the Himalayan pine (*P. wallichiana*) but much hardier.

For a coarser texture, few greens are more sprightly than that of the Chinese pine (*P. tabuliformis*). The familiar Canadian hemlock (*Tsuga canadensis*) provides a finer foliage texture and makes a good neighbor. It is muted in color but the layered branches with shadows beneath, seem by contrast, to have highlights at their tips. Some firs (*Abies* spp.) are much more lively in their shade of green than are others.

Hollies are good company for rhododendrons too, but not the so-called "blue" hybrids with their leaden foliage. The spry green China Girl and its pollinator, China Boy, are a happier combination.

The conventional large-leaved rhododendrons are almost overpoweringly architectural and massive in their bulk a few years after planting. Formal conifers such as the Nikko fir (*Abies homolepis*) and many spruces are so geometrically triangle-shaped that they accentuate the appearance of globes, cubes and pyramids of solemn rhododendron foliage. The loose, informal growth of the Japanese red pine (*P. densiflora*) and the Japanese white pine (*P. parviflora*) are much more pleasing.

Deciduous Trees

As accents not essential to the bare bones design, magnolias are among the best companions for rhododendrons. They have deep, uncompetitive roots and their leaf size is compatible. *Magnolia watsonii,* a small tree with magnetically scented white flowers and a red central boss, is a star in my plantings.

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Trees with a heavy foliage canopy can be a problem because of excessive shade. Those with pinnate leaves are superior. If they are leguminous such as locusts or have fragrant flowers such as yellow-wood, rhododendrons can be planted directly at the bases of their trunks. The Japanese pagoda tree (*Sophora japonica*) with its long panicles of yellow flowers from July to September is also a good choice.

A small flowering cherry, *Prunus* 'Hally Jolivett', makes a charming foil for rhododendrons. So do silver-bell (*Halesia monticola*) and dogwoods.

The redbud or judas tree (*Cercis canadensis*), especially the clear pink cultivar, 'Withers' Pink Charm', or its white counterpart are attractive alternates. Larches are an animated green, as is the golden larch (*Pseudolarix amabilis*) which shares with rhododendrons an abhorrence of alkaline soil.

Among deciduous trees used primarily for shade, oaks are preeminent. Tulip poplars (*Liriodendron tulipifera*) often harbor aphids. Their excretions falling on foliage nourish a black fungus which is unsightly and injurious to rhododendrons. Also the big, western-world maples have voracious roots and are undesirable.

If the gardener is using the conventional "island" planting of rhododendrons in segregated groups, plants in each island should bloom at about the same time. Wilted, fading flowers alongside a specimen at the height of its freshest, most appealing bloom, are a dispiriting distraction.

New Varieties

Only hobbyists seem to be aware that rhododendrons are now available which bloom as early as the first of April and as late as mid-July in the northeastern United States. The century-old association of rhododendrons with Memorial Day persists. For those who want to add flash to their warm weather recreational activities, such rhododendrons as 'Summer Summit' and 'Summer Snow' are available.

The conventional large-leaved rhododendrons are not good dooryard shrubs in the cold Northeast. Plants flanking an entrance become increasingly naked. Leaves curl more tightly as the temperature drops and expose an unattractive scaffold of seemingly bare brown stems.

A bright new array of early blooming, small-leaved rhododendrons have splashy effects at a bleak season before trees are in leaf. Most are super-hardy.

Now there is 'Wally', deep pink; 'Laurie', a pale shade of pink; 'Llenroc', light pink, but not fully evergreen; 'Olga', and 'Elite' a range of white to pink. 'Malta', with semi-double clear pink flowers reminiscent of miniature roses is perhaps the most floriferous of all, and 'Hudson Bay' is a dense, handsomely evergreen plant with a meringue of profuse white flowers.

A catalytic addition is an underplanting of yellow daffodils. With shadblow overhead, the total is probably the most colorfully radiant landscape effect that can be contrived at that season. ❦

How Tall Is That Tree?

The Dawes Arboretum Newsletter, May 1984

You can calculate the height of a tree if you can measure the length of its shadow. First, measure the length of the tree's shadow. Then hold a yardstick upright near the tree in the sun and measure the length of the shadow cast by the yardstick. (All of the measurements should be in feet.) Use the following formula to calculate the height of the tree: $X = (3 \times A) \div B$, where X = the height of the tree, A = the length of the tree's shadow, and B = the length of the yardstick's shadow. (The formula works because the height of the tree divided by the height of the yardstick is in proportion to the height of the tree's shadow divided by the height of the yardstick's shadow, or $X \div 3 = A \div B$.) ❦

John L. Creech

Japanese white birch in the wild in Japan

Asian natives for American landscapes. . .

JAPANESE WHITE BIRCH

Dr. John L. Creech

A plant collector is always gratified to learn that one of his introductions has made it as a cultivated plant. One example of this for me came with 'Whitespire', the new cultivar of Japanese white birch (*Betula platyphylla japonica*). I collected the seeds of this white-barked birch twenty-seven years ago in a remote alpine meadow in Japan. Dr. Ed Hasselkus, University of Wisconsin, Madison, secured the official cultivar name.

But more important, the selection of 'Whitespire' demonstrates that collectors must collaborate closely with arboretum horticulturists who are willing to cultivate and observe new introductions. They must also work with nurserymen who are willing to take the risk of production.

Many introductions remain hidden away in botanical gardens, never to emerge—unless they get into the hands of research horticulturists. We have a bewildering array of introduced species in our living collections. It behooves modern plant collectors to emphasize such factors as distribution and variability of promising species

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to give research horticulturists the array of information and material they require.

The difficulty for collectors, of course, is that they may not always recognize potentially useful types. That is why it is important to sample the natural range of a given species. This requires several collecting trips and sustained activity in a given geographical region. Japan is a good location because of its high proportion of woody plants, the compactness of the country and the number of species used in gardens.

'Whitespire' birch was the second introduction in my collection career in which follow-up research disclosed significant pest resistance, a factor that obviously could not have been determined in the wild.

The other excellent example is *Lagerstroemina fauriei,* which I introduced into cultivation from Yakushima Island, south of Kyushu, in 1956. Although the species is attractive in itself, it was not until later that its true value was realized. Dr. Donald Egolf, US National Arboretum, Washington, DC, discovered it was resistant to powdery mildew and incorporated the resistance into hybrids with common crape myrtle.

Garden Trees

Birches are desirable subjects for gardens, despite some of their cultural limitations, because they remind one of distant meadows and wilderness streams. In Japan, there are eleven birch species. Some of these have recently acquired significant cultural status.

Betula platyphylla japonica is the one most commonly found in Japanese gardens because of its rather pyramidal shape and chalky white bark with narrow horizontal lenticels. The leaves turn bright yellow in autumn, and it has a greater range of adaptability than other Japanese birches. In Japan, it is usually planted in small groups to create a natural setting. Sometimes it is used for bonsai. In northern Japan, it is planted as a roadside tree.

The wood is frequently used for furniture, pulp, and fuel. The white bark is often employed in handcrafts. The Japanese name, *shira-kanba,* simply means white birch.

Although it is not sold extensively in American nurseries, the advent of 'Whitespire' as a borer-resistant selection should make it considerably more popular. Several research institutions and arboretums are engaged in wide-ranging research that should result in many elite selections.

Uneven Distribution

Japanese white birch is a geographic extension of the Asian species. It is widespread in Hokkaido and sporadic in central and northern Honshu. Unlike the other Japanese species of birch, it has an interesting disjunctive distribution.

There is a concentration in northeastern Honshu around Mt. Hakkoda. A fairly extensive but sporadic pattern of distribution exists in central Honshu from about Fukushima Prefecture south to Nagano Prefecture, roughly the region known as the Japanese Alps. The seed collection that produced 'Whitespire' was gathered in this region in the Yatsugatake Mountains.

Japanese white birch is found mostly in open moist alpine meadows along with Hinoki false cypress, Japanese azalea (*Rhododendron japonicum*), various holly species and deciduous shrubs. It does not invade the highest elevations, probably those above 2500 meters (8200 feet).

On the slopes of Mt. Fuji, Japanese white birch is widespread in the lower meadows. As the summit is approached, it is replaced by *Betula ermanii,* which grows to the tree line, where it is a gnarled dwarf tree. Under these conditions, *B. ermanii* is especially picturesque with contorted orange-white branches. For this reason, it is popular as a bonsai subject.

In its natural habitat, Japanese white birch attains about twenty-five meters (82 feet) in height. The bark peels in paperlike flakes, and young branches are brown, growing in a somewhat zigzag fashion. Japanese gardeners consider Japanese white birch tolerant of dryness, despite its rather moist natural habitat. It does not grow well on slopes.

(Readers seeking more precise details on Japanese white birch 'Whitespire' can write to Thomas S. Pinney Jr., Evergreen Nursery Co. Inc., Sturgeon Bay, WI 54235.)

HELPING A TREE RECOVER FROM DEFOLIATION

Defoliation of a shade tree by gypsy moths or other leaf-feeding insects usually is not considered a serious problem. The problem is more serious when the defoliation occurs two or three years in a row. It is also more serious a problem with evergreens such as pines which cannot replace lost needles.

Charles Dunham, extension horticulturist with the University of Delaware, offers some things to keep in mind if your trees are defoliated.

When deciduous trees lose their leaves early in the season they soon put out new ones, Dunham says, and the situation does not look too bad. But loss of foliage will reduce growth and also affect flower- and fruit-bud formation.

If the defoliation has occured two or three years in a row, or if the tree is under some other stress as well (such as drought), it may go into a general decline. Then dieback or even death can occur, Dunham says.

There are a number of ways to reduce the effects of defoliation on deciduous trees, Dunham says. Basically they involve reducing other stresses and encouraging the tree to rapidly generate new leaves. Your first concern is to make sure the affected trees get enough water. This is especially important during periods of dry weather. Apply enough water to soak the soil in the root zone to a depth of 12 to 18 inches. This means about a gallon of water for each square foot of soil area under the tree canopy. Water the trees every two weeks until the new leaves are fully developed and take care to make sure the water soaks in and does not run off.

You can hasten the regrowth of the leaves by feeding the trees with a high-nitrogen fertilizer, he adds. This is especially important if the tree is a valuable ornamental that has been weakened by other stresses besides the defoliation. The fertilizer can be applied in liquid form either to the roots or as a foliar spray on the developing leaves.

To feed the roots, Dunham recommends dissolving a soluble fertilizer in water and applying it with a root feeder in the area under the tree canopy. Use 2 pounds of fertilizer in 100 gallons of water and apply 5 gallons of this solution for each inch of trunk diameter. The fertilizer itself can have a formulation of 20-9-17 (20-20-20 oxide form) or 30-4-8 (30-10-10 oxide form).

Dunham says expanding young leaves have a high capacity to absorb nutrients, so a foliar feeding can also be effective. Special mixtures, with the nitrogen in the form of urea, are required for foliar feeding. These generally have ratios of 30-4-8. Dissolve these in the ratio of 2 pounds of fertilizer in 100 gallons of water and apply to the leaves and branches, spraying to the point of runoff. Apply the first time when the leaves are about half expanded, and repeat once or twice as needed.

Evergreens will not regenerate new leaves in the current season, and the severity of injury will be in direct proportion to the amount of defoliation that has occurred. Foliar feeding will not be effective, but a fertilizer application in the fall or early spring will help promote growth the following year. Broadcast ¼ to ⅓ pounds of actual nitrogen per 100 square feet of area underneath the spread of the branches. In addition, keep a careful watch during the following growing season to prevent further defoliation by gypsy moths or attacks by other insect pests that will further weaken the tree.

A tree that was in active, vigorous growth at the time of defoliation will suffer less than a tree that was already under stress from other causes, Dunham concludes.❦

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MINIMIZING WINTER INJURY TO ORNAMENTALS

Francis R. Gouin

There are a number of steps that can be taken to reduce winter injury of ornamentals in the landscape.

Select only plants that are known for their winter hardiness. Winter hardiness is a *genetic* factor. It cannot be chemically or culturally increased for a prolonged period of time over and above the inherited genetic hardiness. In areas where plants are to be fully exposed and in adverse, stressed locations, select only species that have a long history of hardiness.

Architectural structures like buildings, walls and mounds drastically alter environmental conditions. Reflected light from walls and reflected heat from masonry add stress to evergreen plants during cold, sunny winter days. Placing broadleaf evergreens under such conditions often results in death or injuries from scorch or desiccation. Scorch is a combination of excessive transpiration caused by high light intensity, heat, and the inability of the plant to translocate sufficient water through the stem to the foliage because of freezing temperatures. In such locations, deciduous plants and certain narrowleaf evergreens with adequate winter hardiness and drought resistance are more suitable. If less winter-hardy species are desirable, plant them on the northern and eastern sides of walls, buildings, and mounds. These architectural structures will provide some winter protection from scorch.

Summer and Autumn Care

Late summer irrigation has been reported to be an effective means of minimizing winter injury. Providing adequate irrigation during the months of August and September is more effective than watering thoroughly just before the ground freezes. However, watering the plants thoroughly just before the ground freezes assures an ample water supply and delays freezing of the soil. A wet soil is much more resistant to freezing than a drier soil.

Contrary to many beliefs, fall fertilizing with nitrogen can help reduce winter injury to broadleaf and narrowleaf evergreens and improve spring growth. In nitrogen-deficient soils, many broadleaf evergreens (such as azaleas, rhododendrons and hollies) often drop their lower leaves during winter months. Fall fertilizing with 50 percent organic nitrogen after a frost seems to be effective. However, the fertilizer application should be delayed until *after the first killing frost* and should not be applied on plants that are exhibiting fertilizer stress.

Mulching

Although the natural tendency is to mulch in the spring, mulching should actually be done in the fall. Fall mulching takes advantage of the insulating value of organic mulches. Loosening existing mulch or applying a fresh layer of mulch will help insulate and keep the soil warmer. A good layer of fresh mulch will also help minimize the depth at which the soil will freeze. However, for those growing hybrid tea or floribunda roses, mulching the graft union with soil should be delayed until just before the ground freezes. Mulching roses too early causes a de-hardening of the graft union and makes the canes more susceptible to cold injury.

Exercise caution when mulching slopes that face south or west and landscape plantings near structures facing west or south. A heavy mulch in these areas will prevent the ground from thawing rapidly in late winter, when the moisture needs of the plants are increasing.

Avoid over-mulching. Over-mulching of landscape plants is becoming a serious problem. It causes suffocation of the original root system and encourages new roots

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to grow into the mulch layer for those species that are able to root readily. Because the mulch layer is elevated and does not retain water well, roots developing into this layer are extremely susceptible to minimum root-killing temperatures. Many over-mulched plants were lost during the winters of 1976–77 and 1983–84 because the majority of their roots had developed into the surface mulch layer. Ornamental plantings should be mulched only when necessary, and mulch should not be piled around the stems. Often you need only to loosen the existing mulch to increase its insulating value and appearance.

Select only plants with low root-killing temperatures for growing in raised planters or containers. Minimum root-killing temperatures should be of primary concern when selecting plants for these uses. Although only the minimum killing temperatures of immature roots are reported, it can safely be assumed that the killing temperatures of mature roots will be several degrees colder. This means that if minimum root-killing temperatures are measured in the soil or growing medium around the roots, the plants have a good chance of surviving because the mature roots are more cold-hardy and able to generate new roots. This will have a dwarfing effect on plant growth, but it may not be noticeable to the untrained eye. Where less root-hardy plants are desired, it may be necessary to install heating cables to prevent the temperature of the soil or growing medium from dropping to the root-killing range. ❦

Elizabeth Scholtz Honored

The American Horticultural Society has presented its highest award—The Liberty Hyde Bailey Medal—to BBG Vice President Elizabeth Scholtz.

In addition to the Society's coveted award, Miss Scholtz was chosen this year by the Women's Division of the New York State Fair to be honored as "Woman of Distinction" in the field of agriculture.

Miss Scholtz became Vice President in 1980. She had served as Director of the Garden from 1972 to 1980. Earlier, she was with the Instruction Department for eleven years as head of the Adult Education Program.

Her work in dye plants at the Garden led to a *Plants & Gardens* handbook on the subject and the critically acclaimed documentary film, "Nature's Colors—the Craft of Dyeing with Plants." As BBG tour director, she has led horticultural excursions worldwide.

A graduate of the University of Witwatersrand, South Africa, Miss Scholtz has been awarded honorary doctoral degrees from Pace University and Long Island University. In 1981, Swarthmore College presented Miss Scholtz with its distinguished Arthur Hoyt Scott Garden and Horticulture Award for having "devoted her career to inspiring people's interest in horticulture—from the smallest child to fellow professionals."

She is well known nationally and internationally as an author and lecturer on popular horticulture and botanical subjects. ❦

GARDEN MULCHES WORK LYING DOWN ON THE JOB

Ron Sissons

Mulch serves as a barrier between the soil surface and the air to greatly reduce evaporation of water. Most mulches also prevent additional moisture loss by suppressing weeds that would otherwise compete for soil water (and would add insult to deprivation by transpiring most of their ill-gotten gain out to the atmosphere).

Thus mulch allows the fertile top layer of soil to remain moist, and becomes a happy foraging ground for plant roots. It is an especially good weed suppressor where crop plants have shallow roots and cultivation can cause damage. Newly-planted trees and shrubs, especially those set out in spring, should be mulched if supplying them with water is a problem. Obviously there is little point to mulching a dry soil, so water thoroughly first.

The range of mulching materials runs from organic substances like straw, grass clippings, sawdust and peat, through minerals like stones and gravel, to manufactured items like plastic film.

Organic Mulches Feed the Soil

Keep in mind that mulching materials vary in the amount of water they allow to pass through to the soil. **Straw** allows good penetration and doesn't absorb much of the water in the doing. To suppress weeds, however, you'll need a loose layer ten inches deep at spreading, to end up with a four-inch layer after compaction. And the straw itself may contain cereal seeds that in your garden would be weeds. Straw mulches are too bulky to use on an intensively cropped vegetable plot, and not pretty enough for your ornamental garden.

As with most organic mulches, straw keeps the soil cool in summer, so it should not be applied before the soil has had a chance to warm up or nitrification will be retarded and growth consequently reduced. By the same token, it would not be a happy choice for heat-loving crops needing a warm soil to mature properly.

Lawn clippings make a good mulch for adjacent rosebeds and shrub borders (if weedkillers have not been used on the lawn). Because of a tendency to heat up, a mulch of lawn clippings should be dried for a day or two, then put down in successive applications. Heat buildup in fresh lawn clippings could damage soft plants such as some vegetables, but the heat does have the advantage of discouraging slugs and snails. The nitrogen content of clippings is excellent, so they're good soil-feeders after bacteria have broken them down.

Sawdust is a relatively permanent mulch, it is so slow to break down. Thus it is well suited for use in a perennial erop like asparagus, some small fruits, or on an herbaceous border. Slugs appear to dislike it, a real plus for gardeners tormented by these slimy little fellows. Don't use any from the Western red cedar—it is toxic to some plants.

As sawdust slowly becomes incorporated into the soil the microorganisms breaking it down will rapidly deplete the soil of nitrogen. Be sure to provide your plants with some nitrogen fertilizer, and watch for signs of deficiency (paling of the leaves). Because sawdust mulch has a heat-reflective surface, in very hot-summer areas a sun-seald injury to plants can develop.

In Britain, **pulverized conifer bark** is showing promising results as a mulch. It has a very low rate of breakdown (a two-inch layer lasts three years). There still seems to be a question whether you need to add some nitrogen when you mulch with bark. In any event, since the pH of conifer bark is about 5.5, it may be necessary for

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those working with acid soils to add lime when the mulch is incorporated into the soil. Pulverized conifer bark has an ornamental value because different species come in different shades of browns and golds. This is used by some nurseries in California, but so far as we know is not available in the rest of the U.S.

Inorganic Mulch

Stones and gravel make satisfactory mulch for conserving soil moisture, but beyond that lies the question of what to do when the crops need rotating. Judging by an account of an English writer about a Polish apple expert's visit to China, the Chinese have the answer: stay with one crop, and make that crop trees. He noted that in a very arid area of China, one orchard was in much better health than its neighbors. It turned out that the soil of this orchard had been completely covered with a four-inch layer of small stones collected from a nearby river bed.

The development of **plastics** brought benefits to horticulture, not the least of which was using plastic film for mulch. Unlike the organic mulches, of course, the plastic doesn't help enrich the soil. However, it transmits the sun's rays to the soil, so instead of keeping the soil cool it warms it considerably, improving and speeding plant growth.

Transparent film is more warming than black, but the latter is superb for suppressing weeds. Both types conserve moisture already in the soil but prevent fresh supplies from entering unless you perforate them, and that allows weeds to grow through the openings. Plants to be mulched with plastic should be planted on ridges through holes cut in the plastic. Rain or irrigation water thus runs off into the channels between the ridges and sinks into the soil. Hold the film strip in place by covering its edges with soil.

You may want to try plastic sheeting in landscaped areas in conjunction with gravel or bark chunks. Put the bark over the film (which is available in many widths) and make small slits at intervals to let water pass through. Commercial slitted row covers are available at garden stores.

Aluminum foil is, apparently, showing promise as a mulch for an unusual reason. Its reflected glare has been found to be an aphid repellent, a factor of some importance where aphid-spread virus diseases are a concern.

Reflections on the Water Table

Mulch is a fine moisture-preserver in the garden. It can also help to know something about the water table. Where is it? How can you tell?

Some gardeners never have to think about the water table—it is neither too high, giving them a long mud season in spring that postpones their planting unless they have well-raised beds; nor too low, leaving them in semi-desert country, like that found in the Southwest.

If the water table (the underground area where water pools within the earth's crust) is deep enough to let rain percolate below the root zone of plants, you're not likely to have many drainage problems. However, layered soils sometime impede gravity's pull on the water.

When one type of soil overlies another, water movement can be slowed or stopped at the interface where the layers meet. To make matters worse, the upward movement of water by capillary action may be hindered by the interface. Usually this problem develops where soil has been brought in, and may be prevented by creating a transitional layer in which the new soil is mixed with the native soil.

Another drainage problem may be created by a layer of impervious soil called "hardpan"—usually a fine-textured soil that has been compacted. Occasionally, owing to chemical reactions in the soil, particles comprising the hardpan are almost cemented together—just ask some of our gardeners in Tucson who break their soil with a pick-axe! On a wider scale, breaking the subsoil with a special plow can help, but there have been cases where would-be farmers resorted to dynamite.

To learn whether artificial drainage would help your garden, remove a core of soil with a soil auger. Soil in need of draining will have rusty or black patches; the depth at which these occur will indicate the point at which drainage is impeded. ❦

McWorter

Spider-mite webs in leaf axils

DON'T DECLARE WORLD WAR III IN YOUR WINDOW GARDEN

Elvin McDonald

In the reader survey I have been conducting, insects are far and away the most persistent problem with indoor plants—in windows, light gardens, and home greenhouses. The same may be true outdoors, but here I want to have a heart-to-heart about how we can keep container plants healthy without endangering our own health.

My awareness is up because of recent alarming observations such as a fellow garden writer lamenting about how hard it is to control thrips in certain gesneriads but, not to worry, such-and-such pesticide will do them in—and possibly us too, so best wear a respirator and rubber gloves. I ask you, is killing thrips on a houseplant worth all this?

What about systemics? Granules or sticks, scratched or stuck in the plant's growing medium—the idea is that after a few days these will render the juice of the plant toxic to sucking insects. An apparent clean kill, no harmful fumes, no dressing up for World War III.

Unfortunately, in my own tests the sticks have been amazingly ineffective. I gave up using the granules years ago, having observed that the bugs always came back and plants in treated soil suffered generally declining health. Now I am told that rose growers have observed the same behavior in soil beds treated repeatedly with systemics.

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When dozens of sticks, different brands, failed to halt an attack of mealybugs on a big Hindu rope hoya, I tried dipping it in malathion. That smelled toxic, which suggested I ought to be wearing a respirator or get out—along with the household pets—and it didn't help at all. (Malathion has a relatively brief shelf life; after nearly killing a friend's prized collection of container specimens of Japanese cutleaf maple, I stopped using and recommending it.)

Rubbing Alcohol, Soap and Water

The cure for my hoya has been regular use of cotton swabs dipped in rubbing alcohol; literally wiping out the mealybugs one-by-one. This takes patience and perseverance, but maybe if we don't breathe and ingest all kinds of toxic materials, we will live long enough to be patient and persevere.

And what about those spider-mites? I have for years passed on the following advice of other horticulturists and plant pathologists: apply a miticide such as Pentac or Kelthane. Pentac I haven't used. Kelthane has powerful fumes, renders spray-misters clogged within minutes, beyond my ability to unclog them. A solution made up in a plastic pail for dipping the plants left the inside surface of the pail chemically altered, almost sticky to the touch, and persistently foul smelling.

For spider-mites I am back to soap and water: According to an article in the October-November '84 "Harrowsmith" (a Canadian magazine on the order of "Mother Earth News"), Ivory Liquid dishwashing detergent is consistently a front-runner in experiments using insecticidal soaps. One teaspoon to a quart of water works well, but control means spraying every few days for weeks without fail. (*Note:* Ivory Liquid is not licensed for this use and the manufacturer says the concentration can vary.)

If fungus gnats, springtails, or other creepy-crawlies are observed in houseplant soil, malathion is sometimes recommended as a drench. One writer blithely advises, "This should rid the soil of the pests for the rest of the season." And what about all the other life that exists in a vital growing medium? Mostly such insects are harmless. A spray made from soaking cigarette or cigar butts in water will kill a serious infestation; a drench using some laundry soap, not detergent, will certainly effect discouragement. Personally I have never in forty years of pot gardening found any treatment necessary.

Where all the everyday indoor garden insects are concerned, spider-mites included, I have had excellent results with Safer's Insecticidal Soap, the first such product to gain widespread acceptance—and now or soon-to-be joined by numerous other brands. As with Ivory Liquid and water, repeated applications are necessary. And as with any pesticide, don't apply while the foliage is either sun-drenched or even slightly wilted. (Euphorbias, including poinsettia, and nasturtiums are notably sensitive to applications of Safer's and other remedies should be used.)

Because more and more gardeners are thinking twice before using harmful chemical pesticides, there will soon be separate shelf displays for natural pest controls at local garden centers. Reuter Laboratories' "Attack" line includes a chemical-free way to kill mosquito larvae that has worked like a charm in municipality testing (Summer 1984: New York, New Orleans, Hilton Head Island), not to mention the control of all kinds of caterpillars (gypsy moth, tent, inchworms) and tomato worms.

In the Spring when we celebrate life, it seems appropriate for us gardeners to renew our endeavors to promote wellness in the soil and in the air. If it takes a deadly chemical to maintain a plant, why not grow something else?

Since bonsai have traditionally been lovingly cultivated, trained, and nurtured for generations, even passed along as family heirlooms, they illustrate well the desirability of gardening with safe materials. Each bonsai evokes an appropriate adjective, but some of the prettiest to my eyes are small-flowered Japanese cultivars of azalea.

Everyone knows that azalea leaves may be attacked by spider-mites, or the bud-shoots by aphids. There was a time in the 1950s when the standard control measure would have been applications of DDT. How foolish when a little soap and water would have done nicely. ❦

Illustration: *A Discourse on the Virtues of the Rose* from *Rosa Gallica* by Champier, Paris, 1514.

Strong opinion on a pastoral subject. . .

SOME REFLECTIONS ON THE PHILOSOPHIES OF GARDEN BOOKS

Noel Perrin

One of the unlikeliest of all garden books is a science-fiction novel called "The City and the Stars," an early and classic work by Arthur C. Clarke. In it he is imagining the earth about a billion years from now, with

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only two surviving cultures: a small country called Lys and a city called Diaspar. The people in Lys are gardeners; those in Diaspar are not.

Diasparites have some other consolations, though, such as being immortal and having telepathic machines that can instantaneously synthesize whatever they want. All they have to do is frame the thought and the machines deliver great art, perfect tulips, tender fresh asparagus—whatever the heart desires.

Early in the novel a young man from Diaspar named Alvin slips out of the city and makes his way to Lys. One of the things that surprises him most when he gets there is to find that the Lysians go to the trouble of raising flowers when they could perfectly well have their machines make tulips. Not only that, they grow fruit. The village where Alvin is staying is famous for superb peaches, as well it might be: the villagers have been improving the strain for 10,000 centuries. "But when Alvin ate some choice samples, they seemed to him no better than he could have conjured up in Diaspar by no more effort than raising a finger." The book makes clear that Alvin's taste buds are to be trusted.

So if it is not a matter of obtaining top quality, why do people in Lys bother to grow tulips and peaches? The answer, I think, gets to the very heart of why people garden. After all, artificial flowers and plastic plants have reached a high level in our culture—high enough to fool the eye. You often see people in bank lobbies or fast-food outlets surreptitiously touching the greenery to see if it is real.

A living plant, here or in Lys, provides two things that an artificial plant does not. One is change. The bulb sprouts, grows, flowers. Even more important, a living plant has a will of its own, and the interplay between gardener's will and plant's will is about seven-eighths of what makes gardening interesting. You want it to flower for Christmas; it decides to flower in November. You retaliate by putting it in a cooler place and cutting down on its water; it promptly lets three leaves go limp. Chastened, you take it back to the window and step up its water; it triumphantly proceeds to flower.

Obviously drama like this is not possible with plastic tulips or anything else that is not alive. With the plastic you can have the results of a glowing garden but you cannot have the process of getting there. Process is another name for life itself.

Here we have a clue to why some garden books are so much more interesting than others: some are static and others have motion. The extreme case of static garden books is the hefty volume full of gorgeous color photographs—the great gardens of Europe, some famous estate on the Hudson. There's no harm in such books, but neither is there much good.

The "Active" Sort

At the other, or active, end of the spectrum is the book of directions. Most gardeners have several and occasionally even consult them. The thing to avoid here is any book with the word "complete" in its title. The main reason, of course, is that climates are local and limited, and any universal gardening book is going to consist mainly of advice that does not apply.

Take *The Complete Book of Gardening*, edited by Michael Wright and published by Warner Books (paperback, $14.95). Mr. Wright has a really distinguished staff of garden experts working for him; in many ways they produced a fine book. Unfortunately, however, it sprang from the same impulse that multinational corporations do: the impulse to make money simultaneously in as many markets as possible.

Mr. Wright is English and the book was originally published in London. The feel of the book (not to mention its "colourful" spelling) is thoroughly British. But the number of gardeners in Britain, though large, was not large enough to satisfy the publisher. From the start it was planned for sale in the United States and Canada—with no expensive retooling, either.

The result is an approach something like that of the manual that comes with a new car. Car manufacturers offer innumerable alternate sections—tire pressure is so much if you have the two-door sedan, a quite different amount if you bought the station wagon. Skip this page if your transmission is manual, and so on.

The Complete Book of Gardening is considerably better edited than the average car manual, so there are no sections you have to skip. The text is carefully international: if you say "apple," you must also say "pippin." But multiple marketing creates many problems, and ingenuity cannot solve them all.

Take the page devoted to corn. The editors had a mighty problem with corn. There is really no way you can tell how to raise it both in the familiar style you would use in an American or Canadian context and in the here's-something-exotic-but-delicious style you would select if addressing British gardeners.

The editors opted for the latter, and most of the page is Simple Directions for Englishmen Who Want to Try Sweet Corn. By the end of the page the crop is ready for harvest; that is, it is time to go get a few ears for dinner. As the British editors put it, and this is my favorite sentence in the whole book: "Carefully pick or cut the cobs from the stems." Maybe if you were cleaning up after a raccoon you might do that.

Transcendent Literature

Finally, there is a class of garden books that are neither passive experiences of the great gardens type nor active directions like that minor classic of the food revolution, for example, Nancy Bubel's *Vegetables Money Can't Buy, But You Can Grow* (David R. Godine Publisher, paperback, $6.95). Books in this class are also active—they belong to Lys rather than Diaspar—but the action is entirely mental. You don't go out and plant anything; you stay inside and think.

Sometimes it is a replicative thought. The author has, right there on the page, worked his or her way toward some view of compost or of garden colors in such a masterly fashion that the reader thinks the thought, too. Sometimes it's original. The author has said things so interesting and provocative that readers get into a running argument and discover new thoughts of their own in the process. Normally, of course, both kinds of thoughts are prompted by the same book, and sometimes by the same page.

This is, in short, the class of literature about gardening as opposed to instruction about gardening or passive daydreams about gardening. It is having a golden age in America right now. In the last four years alone four such books have been published.

Henry Mitchell's *The Essential Earthman* (Farrar, Straus & Giroux, paperback, $6.95) may be the best known. It is a little bit ponderous and definitely anti-tree. It is also a book so brimming with confidence and wit as to be irresistible.

Then there is Roger Swain's *Field Days,* subtitled *Journal of an Itinerant Biologist* (Charles Scribner's Sons, $12.95). Mr. Swain has a broad itinerary. He writes the natural history of the avocado. He has written about ants as gardeners (they are first rate), about albino flowers (beloved by humans, despised by insects), even about the ivy at Harvard. He is incapable of being dull.

The same is true of Allen Lacy, a complete stay-at-home, the master of the house plant. Mr. Lacy's *Home Ground* (Farrar, Straus & Giroux, $14.95) is probably the ultimate weapon a gardener can use against a nongardener—say, a recalcitrant spouse.

Give said spouse a copy; if out of mere politeness the spouse reads 2 or 3 of the 61 short essays, there is an excellent chance not only that the book will be finished but that a few days later the spouse will be sneaking out to buy a hoya vine or some glory-of-the-snow.

I have saved the best for last. Eleanor Perenyi's *Green Thoughts* (Random House, $15; Vintage paperback, $5.95) has everything, including snob appeal. Though Mrs. Perenyi is American-born and lives in Connecticut, she did her first gardening at her husband's castle in Hungary in 1939.

That is not what she is writing about, however. Connecticut gardening is her theme. Sometimes I think she is the best writer who ever gardened. Othertimes I think she is the best gardener who ever wrote. Either way she has produced a remarkable book. May it last as long as Lys.

RECENT BOOKS WORTH NOTING

In the Library of the Brooklyn Botanic Garden.
(Please order directly from your bookstore, not from the Botanic Garden.)

Gardening Techniques

The Adventurous Gardener by Christopher Lloyd. Random House, New York. $17.95.

Reflections and philosophy from an avid British gardener and writer. Good winter reading if not a regionally precise guide for stateside gardeners.

Anything Grows by Sheryl London. Rodale Press, Emmaus, Pennsylvania. $15.95.

Emphasis is on finding growing space where there isn't any. Lots of ideas for unusual containers. Good reference book.

Cash Crops for the Thrifty Gardener by Geri Harrington. The Putman Publishing Group, New York. $7.95.

Making money from your garden yields can just be a matter of good planning and thorough checking of the market. Here's what you need to know!

The Complete Shade Gardener by George Schenk. Houghton-Mifflin Company, Boston. $24.95.

If you think a shady garden is a problem, here is a book to change your mind. Subject dealt with in depth with lots of creative ideas. Good reading.

The Dry Garden by Beth Chatto. Rowman & Allanheld, Totowa, New Jersey. $9.95.

Personal experience of a respected British gardener. Reissue of an earlier book. General gardening techniques followed by listing of plants for dry situations.

The Garden Book by John Brookes. Crown Publishers, Inc. New York. $22.50.

Beautiful color photographs depict "dream" gardens of every design imaginable. Lots of practical information on how to do it included. Welcome winter reading although illustrations outweigh text.

Garden Construction by Peter McHoy. Sterling Publishing Co., Inc., New York. $6.95.

Basic information for the do-it-yourselfer on garden construction—walks, walls, gates, sheds, building a a greenhouse or rock garden, and so on. Nicely illustrated and practical.

Gardening in Small Spaces by Michael Miller. G.P. Putnam's Sons, New York. $16.95.

Shrinking outdoor spaces require imaginative use. Here are suggestions and ideas galore for all seasons. Lots of illustrations in color and in black-and-white.

Organic Vegetable Gardening by Bob Percival. Tab Books, Inc., Blue Ridge Summit, Pennsylvania. $16.50.

Well organized encyclopedia for the organic gardener. Covers soils, plants, composting, tools, watering, fertilizing. All you need to know and more.

Pick Your Own Farming by Ralph L. Wampler and James E. Motes. The University of Oklahoma Press, Norman. $14.95.

How-to book on operating small acreage with pick-your-own farms. No-nonsense approach.

Plants that Merit Attention: Vol. I—Trees by the Garden Club of America, Janet M. Poor, Editor. Timber Press, Portland, Oregon. 1984. $39.95.

Here is the first volume in a planned series—this one describes 143 species of trees both deciduous and evergreen. Illustrated in color, each entry has three photographs: the tree, and two smaller of details—such as flowers, fruits, bark, or leaves. The text describes the tree, provides cultural information, landscape value, and where mature specimens can be seen. Excellent reference and resource for the gardener. Very thorough, professional piece of work.

The Principles of Gardening by Hugh Johnson. Simon & Schuster, New York. $14.95.

A charming and comprehensive book with history, art, and science applied to the practices of gardening. Lots of photographs of grand designs—mainly in color. This is another book from England and the *first* one we've seen with hardiness zone maps of U.S. and Europe. Also list of indicator plants provided by Fred McGourty, former editor of *Plants & Gardens*.

The Salad Garden by Joy Larkcom. The Viking Press, New York. $27.50.

Attractive book, well illustrated, includes all you need to know in order to grow the stuff of salads. Even includes recipes. Covers many vegetables other than the lettuces.

The Seed Finder by John Jeavons and Robin Leler. Ten Speed Press, Berkeley, California. $4.95.

A listing of seed companies that stock the old varieties. Well organized.

Tips from the Garden Hotline by Ralph Snodsmith. Taylor Publishing Company, Dallas, Texas. $12.95.

Answers to 101 most asked questions by the WOR (New York) radio personality. Good information given in his usual clear manner.

The Victory Garden Landscape Guide by Thomas Wirth. Little, Brown and Company, Boston. $16.95.

This book is a companion to the PBS television series and is one of a series. Lavishly illustrated, mainly in color, the book is divided into months—what one can do. Plant lists, decks, patios, driveways—every aspect of the home ground is covered. Good beginners book.

Water Gardener's Handbook by Philip Swindells. The Overlook Press, New York. $19.95.

The nuts and bolts of building pools, planting waterlilies, stocking with fish—also includes other water plants and those that tolerate wet feet. Problems and recommended solutions. Thorough coverage.

The Well-Chosen Garden by Christopher Lloyd. Harper & Row, New York. $18.95.

Selecting the right plant for the right place can often be a challenge. Here is a book from an author who knows his plants. Ideas galore for the beginner and/or experienced gardener.

Your Yard by the editors of "Better Homes and Gardens" Magazine, Meredith Corporation, Des Moines, Iowa. $9.95.

Another in the series "All About Your House" library. This one covers the outdoor aspects. How to assess what you have and then make the most of it. Gardens, pools, fences, porches, decks, and birdhouses—to name just a few of the topics covered.

British Gardens and Gardeners

The Early English Kitchen Garden by Mary Palmer Cooper. Trinity Press, Nashville, Tennessee. $9.95.

Thesis which studies 16th to 18th century English gardening to determine its influence on the evolution of the kitchen garden. Interesting reading for those who study garden history and historic preservation.

Georgian Gardens: The Reign of Nature by David Jacques. Timber Press, Portland, Oregon. $39.95.

Covers the period 1730–1830 when some of the greatest personalities in British gardening history were productive. Combines plans, prints, and photographs from many sources. Of interest to garden historians, among others.

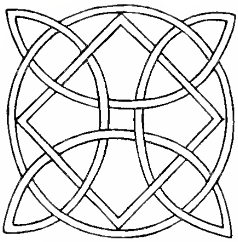
Scotland's Gardens by G. Allen Little. Merrimack Publishers' Circle, Salem, New Hampshire. $17.95.

Good book for the traveler or armchair dreamer. Design history traced with discussion of plant collectors. Descriptions of individual gardens include hours that they are open. Beautiful illustrations, many in color.

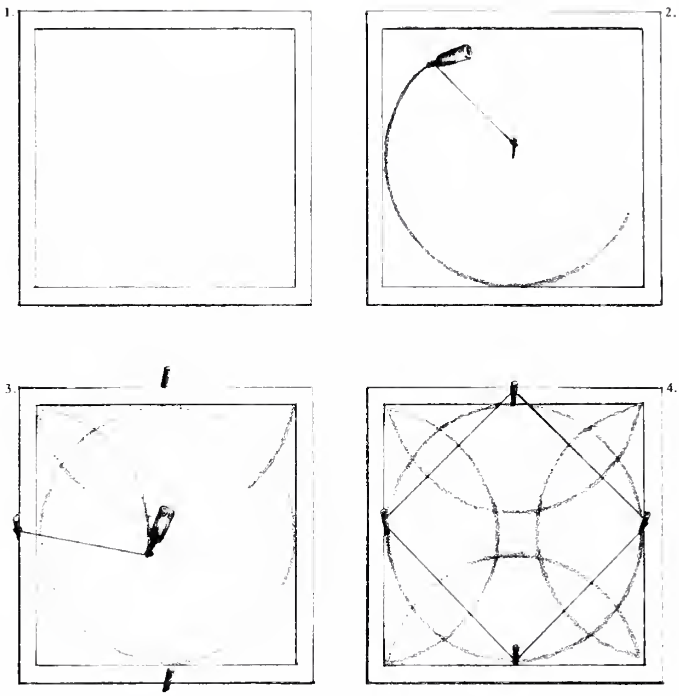
The Victorians and Their Flowers by Nicolette Scourse. Timber Press, Portland, Oregon. $22.95.

The Victorian love for flowers in all their aspects is traced in detail. Nearly nine thousand plants were introduced during this period. It was an age of magnificent

KNOTS



Above: A knot from Thomas Hill's *The Gardener's Labyrinth* (1577) which could be an adaptation of the Duke of Buckingham's heraldic badge.



Right: Making a knot.

1. Make a square bed of the size required.

2. Find the center of the square by stretching strings across it from corner to corner. Place a peg at this center point. Attach a piece of string to a bottle filled with sand. Stand the bottle at the edge of the bed halfway along one side and then tie the string to the central peg. Then, using this primitive compass, make a circle of sand.

3. Next, place a peg outside the bed halfway between two corners and make a semi-circle. Repeat at each side.

4. Now, place the pegs inside the bed and stretch string between them. Pour more sand along the line of the string. Finally, plant with different species of herbs 3-4 inches apart. For example, thyme for the square, hyssop for the semi-circles and marjoram for the circle. Your knot may be planted using only box. Fill the spaces between with colored gravel.

From *Classic Garden Design* by Rosemary Verey, published by Congden & Weed.

gardens and conservatories, and elegance.

Garden Design

The American Woman's Garden by Rosemary Verey and Ellen Samuels. N.Y. Graphics Society, Little Brown & Co., Boston. 1984. $29.95.

A beautiful and extraordinary testament to the American Garden scene. Essays by thirty women from all over the country, many of whom are members of BBG.

Classic Garden Design by Rosemary Verey. Congdon & Weed, Inc., New York. $24.95.

Lively book of garden history with elements and designs that could be adapted to the home garden. Nicely illustrated and interesting reading even if you're not actively looking for ideas.

Designing the Landscape by Richard L. Austin. Van Nostrand-Reinhold Company, Inc., New York. $15.95.

For professionals. A book designed to instruct how to use the natural environment rather than work against it.

Energy Efficient Site Design by Gary O. Robinette. Van Nostrand-Reinhold Co., Inc., New York. $25.95.

The title says it—deals with the impact of sun and wind on natural elements. Studies show how to make the most of nature's elements in a building site.

Garden Design Illustrated by John and Carol Grant. Timber Press, Beaverton, Oregon. $19.95.

Reissue of an out-of-print book. Nuts-and-bolts approach to garden design with stress on the naturalistic approach. The authors are from the Pacific Northwest, but design principles remain universal.

Garden Planning and Design by Peter McHoy. Sterling Publishing Co., Inc., New York. $6.95.

Clear, concise, step-by-step instructions for the gardener who wishes to start a new garden or correct elements in one that exists. Illustrated with color photographs and drawings.

Interior Landscaping by Tok Furuta. Reston Publishing Co., Inc., Reston, Virginia. $19.95.

Interior plants define spaces in more and more large buildings. Here are lists of plants to use for various situations, problems and solutions, and ideas. Lots of information.

Residential Landscapes by Gregory M. Pierceall. Reston Publishing Co., Inc., Reston, Virginia. $28.95.

Although the intended audience for this book includes the homeowner, it appears more geared to the professional. Points made largely through drawings.

Herbs

An Album of Fragrance by Edith G. Bailes. Cardamom Press, Richmond, Maine. $9.95.

Hard to read because of small type but information is good. Instructions on how to make your own perfume, incense, and potpourri.

Herb Garden Design by Faith H. Swanson and Virginia B. Rady. University Press of New England, Hanover, New Hampshire. $30.00.

Ambitious and complex herb garden designs. Plans, plant materials, and photographs. Probably best used by the professional.

In Praise of Wild Herbs: Remedies and Recipes from Old Provence by Ludo Chardenon. Capra Press, Santa Barbara, California. $7.95.

Whether or not the recipes of "the plant-magic men" work, this book is a delight to read. The recipes are the legacy of generations and the brief memoirs are wonderful.

Medicinal Plants of the Bible by James A. Duke. Trado-Medic Books, New York. $49.95.

Reference book on 142 herbs and plants mentioned in the bible. Interesting reading. Very nice line drawings.

Practical Herb Gardening with Recipes by Bryan N. Bunch. Tab Books Inc., Blue Ridge Summit, Pennsylvania. $15.95.

Basic information for the herb gardener from an experienced grower. Recipes are organized and straightforward—step-by-step. Some line drawings.

Oriental Gardens and Gardening

The Art of Zen Gardens by A.K. Davidson. Houghton-Mifflin Co., Boston. $15.95.

History and philosophy of Japanese gardens traced before embarking on how-to aspects. All elements of design covered in clear, concise manner. Helpful line drawings.

Bonsai: Its Art, Science, History and Philosophy by Deborah Koreshoff. Timber Press, Portland, Oregon. $39.95.

In-depth look at bonsai traces its roots back to Chinese art of *penjing*. Author owns and operates an Australian bonsai nursery and teaches and lectures all over the world. Large format book.

The Brocade Pillow by Itō Ihei. Introduction and Commentary by John L. Creech. John Weatherhill, Inc., New York. $22.50.

Based on a 1692 work by a Japanese nurseryman. Documents early cultivation of azaleas. Illustrated with woodcuts and some color photographs.

Classical Chinese Gardens edited by Qian Yun. China Books & Periodicals, Inc., New York. $69.50.

Large-format coffee-table book consisting mostly of color photographs. Pictorial tour through private and public gardens. Exquisite.

The Gardens of Japan by Teiji Itoh. Kodansha International, New York. $85.00.

As the price probably indicates, this is a large format, coffee-table book that is lavishly illustrated with color. History and elements of design described. Many gardens listed with hours for visiting and entrance fees. Beautiful book!

Smaller is Better: Japan's Mastery of the Miniature by O-Young Lee. Kodansha International, New York. $16.95.
Insight into the Japanese mind from a Korean point of view (author speaks Japanese but writes in English—an important point). The Korean and Chinese attitudes are also explained.

Botany

The Plant Observer's Guidebook by Charles E. Roth. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. $9.95.
The subtitle "A Field Botany Manual for the Amateur Naturalist" says it all. Lots of information and projects for hobbyist, teacher, and gardener.

The Facts on File Dictionary of Botany by Elizabeth Tootill. Facts on File, Inc., New York. $21.95.
Informative dictionary covers pure and applied aspects of plant science which include taxonomy, plant pathology, ecology, just to name a few. Good reference.

Botany Illustrated by Janice Glimn-Lacy and Peter B. Kaufman. Van Nostrand-Reinhold Company, New York. $19.95.
Simple text with line drawings which are particularly well done. Basic introduction is followed by groups (bacteria to fungi, algae, conifers, and flowering plants).

Botany in the Field by Jane Scott. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. $8.95.
The subtitle is "An Introduction to Plant Communities," and it is. This book is delightfully illustrated with line drawings by the author. Will make a country walk more interesting even for the casual observer.

Plant Groups

The Book of Cacti and Other Succulents by Claude Chidamian. Timber Press, Beaverton, Oregon. $13.95.
Good introduction to knowing and growing succulents. Update of an earlier edition. Illustrated with line drawings.

The Book of Bamboo by David Farrelly. Sierra Club Books, San Francisco. $14.95.
Arranged in encyclopedic form, this is a sort of "Whole Earth Catalog" of bamboo. Lots of craft projects.

The Book of Edible Nuts by Frederic Rosengarten, Jr. Walker and Company, New York. $35.00.
Highly informative book on the subject of nuts. Includes how they are grown, harvested, and used. Recipes from appetizers to desserts. Well illustrated.

Combined Rose List by Beverly Dobson, 215 Harriman Road, Irvington, N.Y. 10533. $7.50 ppd.
Prepared each year, this is the most complete listing of old and modern roses and where to find specific varieties commercially available.

Growing Begonias by Eric Catterall. Timber Press, Portland, Oregon. $17.95.
Everything you need to know about growing begonias. Begins with history and development, then to cultivation and lists of candidates. Some color photographs and nice line drawings.

Growing Orchids by J. N. Rentoul. Timber Press, Portland, Oregon. $19.95.
This is the third book of a set which covers vandas, dendrobiums, and others. Includes history, culture, and care. Illustrated with lovely color plates—over two hundred. The author has more than forty years of experience in orchid growing.

Growing Roses by Michael Gibson. Timber Press, Portland, Oregon. $18.95.
Every aspect of growing roses is covered by this rose expert. Illustrated, some in color.

Growing Wildflowers by Marie Sperka. Charles Scribner's Sons, New York. $9.95.
Reissue of book written in 1973. Handy reference for growing many wild flowers. Delightful drawings.

Handbook of Cultivated Sedums by Ronald L. Evans. Science Reviews Limited, Middlesex, England. $25.00.
Useful reference work for botanists and gardeners. Species descriptions are in detail, with illustrative line drawings. Color photographs complete the volume.

The Pocket Encyclopedia of Modern Roses by Tony Gregory. Sterling Publishing Co., Inc., New York. $9.95.

Written by a rose grower, this small book describes over three hundred rose varieties—all photographs in color. Brief descriptions of each included.

Roses by Kenneth A. Beckett. Ballantine Books, New York. $4.95.

Slim volume provides step-by-step information on everything you need to know about growing 130 kinds of roses. Line drawings and color illustrations.

Trees: An Introduction to Trees and Forest Ecology for the Amateur Naturalist by Laurence C. Walker. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. $10.95

Lots of facts and folklore about major trees of the United States. Activities and projects included.

Wildflowers of the Great Lakes Region by Roberta L. Simmonds and Henrietta H. Tweedie. Chicago Review Press, Chicago. $5.95.

Lovely line drawings provide main content of this small book. Arranged by season of bloom with short description which contains habitats and flower colors.

Wildflowers of the Northern Great Plains by F.R. Vance, J.R. Jowsey, and J.S. McLean, University of Minnesota Press, Minneapolis. $14.95.

Field guide, although slightly large for the pocket, of plants of this area. Meant for the beginner as well as interested botanizer, it is nicely illustrated with color photographs and line drawings.

The Environment

A Citizen's Guide to River Conservation by Rolf Diamant, J. Glenn Eugster, and Christopher J. Duerksen. The Conservation Foundation, Washington, D.C. $7.95.

"How-to" book on organizing an effective river conservation program. Case studies are included that show how groups of organized, concerned citizens can influence the future of their rivers.

A Killing Rain: The Global Threat of Acid Precipitation by Thomas Pawlick. Sierra Club Books, San Francisco. $14.95.

American journalist living in Canada presents compelling documentation on the acid rain situation. Convincing evidence for clean air legislation which has yet to be passed.

Bioshelters, Ocean Arks, City Farming: Ecology as the Basis of Design by Nancy Jack Todd and John Todd. Sierra Club Books, San Francisco. $10.95.

Based on the results of research at the New Alchemy Institute on Cape Cod. Innovative experiments on experimental environments described.

Dictionary of the Environment by Michael Allaby. Columbia University Press, New York. $50.00.

Reference book which includes terms relating to the concerns of environmentalists. Includes earth science, ecology, and some nuclear power entries.

This Land Is Your Land by Bernard Shanks. Sierra Club Books, San Francisco. $19.95.

Highly personal review of history and controversies surrounding the use of public lands. Environmentalist view presented in convincing manner.

Encyclopedias

A Color Atlas of Fruit Pests by David V. Alford. Sheridan House Inc., Dobbs Ferry, New York. $58.00

Identification of fruit pests made easy by excellent color photographs. Life cycle, damage, and control described for each. Well organized.

The Complete Handbook of Garden Plants by Michael Wright. Facts on File Publications, New York. $18.95.

Made up in the manner of a field guide, although far too large and heavy for the coat pocket, this is a guide to nine thousand cultivated species and varieties. Illustrated with watercolor plates. Although written in England, there is a hardiness map of U.S. Handy reference.

The Concise Encyclopedia of Garden Plants by Kenneth A. Beckett. Merrimack Publishers Circle, Salem, New Hampshire. $19.95.

Lavish color illustrations for each entry of the over two thousand described. Type is small and no translation made for U.S. climate zones by the British author.

The Country Gardener's Almanac by Martin Lawrence. Kampmann & Company, New York. $9.95.

Whole Earth Catalog format arranged by month with projects and chores for each. Origins of information mostly from old magazines.

Dictionary of Geological Terms edited by Robert L. Bates and Julia A. Jackson. Doubleday & Company, Inc., New York. $7.95.

Dictionary for the nonprofessional providing accurate definitions of the vocabulary of the earth sciences.

The Good Housekeeping Encyclopedia of Houseplants by Rob Herwig. Hearst Books, New York. $19.95.

Large-format book arranged in encyclopedic fashion, illustrated in color. Individual entries preceded by general section on culture and care. Some of the plants listed do not make good houseplants, however. First written in the Netherlands.

The Miracle Houseplants by Virginia F. and George A. Elbert. Crown Publishers, Inc., New York. $16.95.

This edition is an update and expansion of an earlier one. Covers all aspects of culture, new species and cultivars of African violets and their relatives. Readable style with lots of photographs—some in color.

Natural Insect and Disease Control by Roger B. Yepsen, Jr. Rodale Press, Emmaus, Penn. $21.95.

A book for the home gardener on protecting plants from insects and diseases without the use of chemicals. Arranged in encyclopedic form for easy reference. Some color illustrations.

Right Plant, Right Place by Nicola Ferguson. Summit Books, New York. $14.95.

Arranged in encyclopedic form with over 1,500 plants described. The author gardens in Scotland but this edition was edited for U.S. by Fred McGourty, expert plantsman and former editor of *Plants & Gardens*. Good reference book.

The World Guide to House Plants by Anthony Huxley. Charles Scribner's Sons, New York. $19.95.

Each plant entry starts with place of origin which gives clues to culture. Liberally illustrated with attractive drawings and color photographs. Good reference. Reads well.

Reissues of Classics

Gertrude Jekyll on Gardening edited by Penelope Hobhouse. David R. Godine, Boston. $20.00.

This is an anthology of Gertrude Jekyll's writings. Another book that demonstrates the resurgence of interest in Jekyll.

The English Flower Garden by William Robinson. The Amaryllis Press, New York. $35.00.

The 15th edition of Robinson's book (there were sixteen) was used for this reprint, as it was the last one he supervised. Graham Stuart Thomas has revised the dictionary section to bring the nomenclature up to date. It is wonderful reading by the "father" of gardening as we now know it. Robinson conducted a crusade for more "natural" gardening as against the "bedded-out" masses of cold-tender plants.

Colour in the Winter Garden by Graham Stuart Thomas. Biblio Distribution Center, Totowa, New Jersey. $24.95.

Reissue of an English classic with some updating and additions. Good reading, but those of us in the colder sections of the U.S. will not have the wide choices listed here.

A Miscellany

Being a Plant by Laurence Pringle. Thomas Y. Crowell, New York. $10.95.

Indicated for twelve-year-olds and up, this book explores the life processes of plants. The interrelationships between plants and insects, birds, and other animals is also included. Well researched and nicely written.

Ceremonial Time by John H. Mitchell. Anchor Press/Doubleday, Garden City, New York. $15.95.

Journey in time with John Mitchell back through the centuries to discover a world beyond official history. Fifteen thousand years of time is covered on one square mile. Interesting.

The Heirloom Gardener by Carolyn Jabs. Sierra Club Books, San Francisco. $9.95.

Why should we be concerned about saving the old seed varieties? Who is preserving them? How do you grow them? Here are all the answers. Good reading. This carefully researched book could prevent further losses of valuable old varieties of vegetables and fruits.

Home Ground by Allen Lacy, Farrar Straus Giroux, New York. $14.95.

Highly readable, entertaining collection of essays from a gardener and writer. Good book for winter reading and/or by the bedside.

Private Lives of Garden Birds by Calvin Simonds, Rodale Press Inc., Emmaus, Pennsylvania, $14.95.

A keen observer looks at common garden visitors. Anyone who is aware of feathered friends in gardening ventures will enjoy this book.

Reflections of Nature by Ella H. Foshay, Alfred A. Knopf, New York. $29.95.

Survey of American flower painting from the 18th century to present. Guest Curator Forhay put together the Spring 1984 Whitney Museum of American Art's show. Her research shows that flowers have relevance to the most serious concerns of artists. Beautiful book.

The Rose in My Garden by Arnold Lobel, pictures by Anita Lobel. Greenwillow Books, New York. $11.50.

For children. Charmingly illustrated slim volume, telling the story of the flowers and other inhabitants of a garden.

Tree Flowers by Millicent E. Selsam, William Morrow & Company, Inc., New York. $11.00.

Although written for children this beautifully illustrated book contains a great deal of information. A dozen-or-so trees are illustrated and described.

U.S. 40 Today by Thomas R. Vale & Geraldine R. Vale. The University of Wisconsin Press, Madison, Wisconsin. $27.50.

Photographic journey across the United States today paired with the 1953 journal of George Stewart. Fascinating record of the changing landscape of America.

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Barbara B. Pesch, *Editor*

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AN INVITATION TO JOIN AND ENJOY

All who are interested in the out-of-doors and the beauty of living things are cordially invited to become Members of the Brooklyn Botanic Garden. Membership includes a subscription to PLANTS & GARDENS, BBG Newsletters, occasional plant and seed "dividends," BBG short courses at reduced rates, and other benefits. Memberships make fine gifts, too.

....

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